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Asst. Director
Okla. G. S.

UNIV. OF MICH.
APR 14 1909

Second Biennial Report

Department of Geology and Natural History

Territory of Oklahoma

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153
.A2

1901-1902

A. H. VAN VLEET, Territorial Geologist

TERRITORY OF OKLAHOMA

Department of Geology and Natural History.

SECOND BIENNIAL REPORT.

A. H. VAN VLEET, TERRITORIAL GEOLOGIST.

1901-1902.

1902.
STATE CAPITAL COMPANY,
GUTHRIE, OKLA.

ASSISTANTS.

Charles N. Gould, Geologist.

Edwin DeBarr, Chemist.

R. S. Sherwin, Assistant in Geology and Chemistry.

Paul J. White, Collector in Botany.

C. D. Bunker, Collector in Zoology.

Territory of Oklahoma,

Department of Geology and Natural History.

Hon. Thompson B. Ferguson, Governor of Oklahoma.

Sir: In compliance with the requirements of section five of an act of the Fifth Assembly of the Legislature of Oklahoma establishing the department of Geology and Natural History, I have the honor to submit the second biennial report.

Very respectfully,

A. H. VAN VLEET, Territorial Geologist.

University of Oklahoma, November 29, 1902.

CONTENTS.

Assistants.......... 2
Letter of Transmittal.......... 3
Table of Contents.......... 5
Introductory.......... 9
General Geology of Oklahoma, by Chas. N. Gould.......... 17
Introduction.......... 17
    Surface and drainage.......... 17

  The Rocks Below the Red-Beds.......... 19

    The Wichita Mountains.......... 19
      Location.......... 19
      Igneous Rocks.......... 20
      Sedimentary Rocks.......... 21

  The Carboniferous Rocks.......... 22
    Indian Territory Carboniferous.......... 23
    Oklahoma Carboniferous.......... 24

  The Lower Permian Rocks.......... 26

  The Red-beds.......... 29
    Introduction.......... 29
    Location.......... 29

  Historical Sketch.......... 30
      Work in Texas.......... 30
      Work in Kansas.......... 32
      Work in Oklahoma.......... 37
      Work of Oklahoma Survey.......... 39

    Classification of Oklahoma Red-beds.......... 42
      The Norman Foundation.......... 43
        The Eastern Division.......... 43

        The Central Division.......... 45
        The Western Division.......... 45
        Nomenclature.......... 46

      The Blaine Formation.......... 47
        The Ferguson Gypsum.......... 47
        The Magpie Dolomite.......... 48
        The Medicine Lodge Gypsum.......... 48
        The Altona Dolomite.......... 48

The Shimer Gypsum 49
  Nomenclature.....49
  The Woodward Formation.....49
  The Dog Creek Shales.....49
  The Red Buff Sandstone.....50
  The Day Creek Dolomite.....51
  Nomenclature.....52

The Greer Formation 52
  The Chaney Gypsum.....55
  The Kiser Gypsum.....55
  The Haystack Gypsum.....55
  The Cedartop Gypsum.....56
  The Collingsworth Gypsum.....56
  The Delphi Dolomite.....56

The Quartermaster Formation 57

Palaeontology of the Oklahoma Red-beds.....58
  The Nardin Locality.....58
  The Orlando Locality.....59
  The Gypsum Hills Locality.....60
  The Whitehorse Locality.....61
  Conclusion 68

On some Vertebrae Fossils from the Permian Beds of Oklahoma, by E. E. Case.

The Comanche Cretaceous 69
  Character of Rocks.....69
  Location of.....70
  The Tertiary.....71
    Area.....71
    Physical Properties 72
    Origin 73
    Extent and Thickness.....74

Oklahoma Gypsum, by Chas. N. Gould.....75

Introduction.....75
  Varieties and Distribution of Gypsum.....76
  Varieties of Gypsum.....76
  Distribution of Gypsum.....76

Historical Resume of Oklahoma Gypsum.....77
  Marcey's Report.....78
  Cragin's Report.....80

Geography of Oklahoma Gypsum........ 84
  Area of the General Region.... 84

Classification of Oklahoma Gypsum Regions......... 85
  Methods Used in Estimating the Amounts of Gypsum.......85
  Kay County Region...... 87

  The Main Line of Gypsum Hills...... 88
  General Description...... 88
  Canadian County.... 90
Kingfisher County...... 91
  Blaine County...... 92
  Woods County.... 100
  Woodward County....... 105

The Second Line of Gypsum Hills 109
  General Description...... 109
  Comanche County........ 110
  Caddo County...... 110
  Washita County...... 112
  Custer County.......... 113
  Dewey County.... 114
  Day County.... 115

The Greer County Region...... 115
  Roger Mills County...... 115
  Greer County...... 115

Approximate Amounts of Gypsum in Various Counties..........118
  Geology of Oklahoma Gypsum........ 119
  Deposition of Rocks...... 119
  Condition of Sedimentation........ 120
  Character of the Red-beds...... 121
  Origin of Gypsum Deposits...... 123
  Theories of Origin.............................123
  Deposition from Sea Water...... 123
  Deposition from Thermal Springs...... 124
  Deposition through Volcanic Agencies...... 124
  Hunt's Chemical Theory of Gypsum Formations...........124
  Disposition through the Action of Pyrites of Iron on Carbonate of Lime.... 125

Oklahoma Mills........ 125
  Conditions of Manufacture...... 125
  The Rubey Mill...... 127
  The Watonga Mill.... 128

The Okarche Mill....................129
The Kay County Mill....................129

Possible Sites for Plaster Mills....................130

Process of Manufacture....................131
Arrangements of Mills....................131
Use of Retarders....................133
General Requirements of a Plaster Mill....................134
Internal Arrangement of Calciners and Machinery....................136
Uses of Gypsum....................136

Plants of Oklahoma, by A. H. Van Vleet....................138
Birds of Oklahoma, by A. H. Van Vleet....................161
Snakes of Oklahoma, by A. H. Van Vleet....................167

INTRODUCTORY.

The Department of Geology and Natural History was established by an act of the Fifth session of the Legislative Assembly of Oklahoma. The object for which the department was created is thus stated in the act providing for the same:

"A Department of Geology and Natural History is hereby established for the purpose of beginning and continuing the geological and scientific survey of this territory, and of discovering and developing its natural resources, and disseminating information in regard to its agriculture, mining, and manufacturing advantages."

In the work thus far accomplished, especial attention has been given to the economic geology of the territory, and to making collections both in botany and zoology. The general geology has, however, not been neglected, and the present report deals at length with this subject.

NATURAL RESOURCES.

The natural resources of Oklahoma that give greatest promise of immediate development, and concerning which capitalists outside the territory are making most inquiry, are its clays, gypsum, salt and building stone.

These subjects, then, are the ones that the department has under immediate investigation, and Prof. C. N. Gould's article, in this report, contains a very complete description of the location and area of the principal gypsum beds, with an account of the development of this rapidly (1) growing and important industry.

BUILDING STONE.

Much data has been collected relative to the building-stone of the territory, but the quarrying industry is, as yet, largely undeveloped and not enough data has been secured for a sufficiently complete report.

The northeastern portion of Oklahoma has immense deposits of limestone of a very excellent quality, and a great deal of stone is being quarried. The cost of getting the stone to the shipping points seems to be one of the greatest drawbacks to the development of this industry.

Much is claimed for the granite of the Wichita Mountains, and while the use of it in construction of buildings, etc., is, as yet, too limited to determine with certainty its real worth, there seems little doubt that it will prove of great value as a building-stone.

It is very certain, indeed, that Oklahoma has plenty of building-stone of excellent quality.

SALT.

There are at least two salt areas in Oklahoma that will be of much commercial importance—"the salt plains of the Cimarron," and "the salt plains of Blaine county."

In both places there are large salt springs the waters of which contain a very high percent of salt, and the cost of evaporation and transportation is the only one connected with its production.

So far this has been sufficient to prevent its manufacture on a large scale, but transportation for the salt with more direct connections with the coal mines, will settle this difficulty and open up this important industry.

CLAYS.

Among the most valuable resources of any state are its clays. The manufacture of building-brick, paving-brick, tiling, and in short, all the products from clay, is of the greatest importance.

This industry is comparatively undeveloped in Oklahoma, but enough has been done to prove that the territory is not lacking in good raw material. A more thorough investigation of this subject is of the greatest importance.

SOILS.

Oklahoma is preeminently an agricultural territory. Its soils are its most important resources. The majority of its inhabitants are directly dependent upon its products.

Experience is largely the determining factor in judging of the suitability of a soil for certain products, and while no one would wish to undervalue experience, it is nevertheless true, that a knowledge of the nature of the soils would often prevent very costly errors in regard to the kind of products a certain soil is best suited to yield. This will be especially true when the land becomes older and artifiicial fertilizers are required.

The study of the origin, constitution, and distribution of the soils of the territory belongs naturally, it seems to me, to the department of geology, and a complete and systematic study of the soils would furnish information of the greatest value to the agriculturalist.

MINERALS.

No deposits of the precious metals are claimed for Oklahoma except in the Wichita Mountains. At the time of the "opening" there was much excitement, and the mountains were filled with prospectors. Companies were formed, and mining stock placed on the market. Many are still sanguine as to the presence of gold, silver, and copper in paying quantities. The department has not investigated the matter except to keep informed as well as possible as to results, knowing that the work of the prospectors would be more extended and thorough than would be possible by the survey at this time, and that the metals, if present, would be discovered.

Copper occurs in small quantities in many portions of the territory. It usually occurs in very thin copper-bearing strata, the ore often being very rich, but not abundant enough to pay for mining.

Near Watonga, in Blaine county, considerable ore has been taken out, but unless more extensive veins are encountered, it can hardly prove of much commercial importance. In the western portion of Beaver county, so I am informed, there are mines of considerable importance. I have never visited this locality, and at this time am not informed as to the extent of the copper deposits.

COAL, OIL, AND GAS.

Newspaper reports of the discovery of oil and gas in nearly all parts of the territory are of frequent occurrence. Many experimental wells have been sunk, and oil and gas have undoubtedly been found in many cases; but there are no wells, as yet, that are known to furnish these products in paying quantities.

From its geological position, oil and gas, in Oklahoma must be at a considerable depth, and the problem must be solved by deep borings. Most of this work will be done at private expense. While it would be unwise, in view of the many surprises of late years in the discovery of these prdoucts, to predict the presence or absence of them in any locality, the depth of the oil-bearing strata may be estimated with considerable certainty, and this knowledge, if made use of, would prevent much waste of money in foolish experimenting.

There are no coal mines of importance in the territory. The eastern portion approaches the coal beds of Indian Territory, and it is not unusual to strike small veins of coal, in this region, some of it of fair quality, in diging ordinary wells. This has lead to some experimenting in the way of deep wells. While the geological horizon would not indicate the presence of coal at a reasonable depth, it is not impossible or even improbable, that local areas of some importance may be encountered.

Fortunately, the industries requiring fuel for their development, are not dependent upon the discovery of coal, oil, or gas within the present limits of Oklahoma. These products are all found in Indian Territory, just on its eastern border, and plenty of fuel is thus assured at a comparatively low cost.

NATURAL HISTORY.

The department is required to make collections in the different lines of natural history, including botany, zoology, and paleontology.

It is urgent that collections be made while the territory is still new, so as to preserve as many as possible of the plants and animals native to this region.

The herbarium now contains eight hundred and thirty-eight different species of Oklahoma plants. The herbarium is classified, and is being arranged in the University so that it will be available for examination and study.

One hundred and seventy-eight species of birds have been collected, and a fine cabinet of skins preserved. The University taxadermist, Mr. C. D. Bunker, is preparing a nice display of mounted birds.

A large and representative collection of the snakes has been made.

Lists of the birds and plants, and a catalogue of the snakes will be found in this report.

The department has been fortunate in discovering fossils, both vertebrate and inverterbrate, in the red-beds, which have settled the long disputed question as to their age. A list of these fossils is included in the report.

Descriptions of the invertebrate fossils, several of them new to science, has been published as a separate bulletin, and is now ready for distribution.

RELATIONS OF THE SURVEY TO THE UNITED STATES GEOLOGICAL SURVEY.

While no official relations exist between the Territorial Survey and the United States Survey, it is the policy to cooperate, as far as possible, with that department in working out the many problems of scientific and economic importance.

Owing to the recent bill passed by congress, appropriating the income from the sale of certain lands for purposes of irrigation, the United States Survey is making very thorough investigations as to the water supply of Oklahoma.

The Territorial Survey will, for the present, confine its investigations mostly to such economic resources as promise to be of the greatest immediate benefit to the citizens of the territory, leaving those that require the assistance of specialists and high-priced experts to the United States Survey.

There is immediate need for a

TOPOGRAPHICAL SURVEY

of the Territory.

It is impossible to secure this within a reasonable time except through the cooperation of the United States Survey.

The maps which will be published by the government as the result of such a survey, show, in different colors, the following principal facts:

"1. Public culture, printed in black; which includes the exact plan of every road, lane, path, railroad, street, dam, public boundaries, names, etc.

"2. The hydrography, or water, printed in blue, including all lakes, rivers, streams, swamps, marshes, reservoirs, springs, etc.

"3. The relief, or surface forms, printed in brown, including the shapes of the hills, valleys, and ravines, their elevations and depressions, and the slopes of every rise or fall in the surface of the land."

Some of the uses of these maps are quoted from the report of the Director of the United States Survey:

"1. Educational. (a.) By promoting an exact knowledge of the country; (b) by serving teachers and pupils in geographic studies.

"2. Practical. As preliminary maps for planning engineering projects. Highways, electric roads, railroads, acqueducts, and sewerage plants many be laid out by them, and the cost of preliminary surveys may be saved. Areas of catchment for water supply, sites for reservoirs, and routes of canals may be ascertained from these maps.

"3. Political. In all questions relating to political or legislative matters. For these purposes they afford accurate information as to the relations of boundaries and towns to natural features.

"4. Administrative and military. In all questions relating to Federal or State administration of public works, as canals, reservations, parks, highways, and as military base maps on which to plan works of offense, defense, camps, marches, etc.

"5. Statistical. As base maps for the graphic representation of all facts relating to population, industries, products, or other statistical information.

"6. Economic. As a means for showing the location, extent, and accessibility of lands, water, forests, and valuable minerals. In this respect these maps are indispensable to State and Federal Bureaus, and to owners, investors, and corporations."

The plan of cooperation is for the State and Government each to bear half of the expense of the survey.

The money appropriated by the State is used to pay for the services of temporary employees, who are usually residents of the state and for defraying the expenses of the field force. The money is thus returned to the people of the state. The money appropriated by the Government is used to pay the salaries of the permanent employees, and for field and office work. The expense of making and printing the maps is all borne by the Government.

It is very desirable that such action be taken by the next Legislature as is necessary to secure the cooperation of the Government in beginning such a survey at once.

OFFICE WORK.

The law provides that the department shall not only make a scientific survey of the territory, but shall be a bureau of information in all matters pertaining to its natural resources. This the department is trying to make as efficient as possible, and if the correspondence increases, as it undoubtedly will, when the publications are circulated, it will be necessary to provide for an office assistant.

PRINTING .

Above all else, provision should be made for printing the report at once. Many requests for it are coming in in advance, and it will require a large number of volumes to supply the demand.

It is necessary that the report be printed, not only in order to get the matter it contains before the public, but the building up of the

LIBRARY

depends upon it.

The library will consist almost wholly of reports of the various State and United States Surveys and Associations, and are received largely as exchanges. The department is collecting these reports as far as possible, but printed reports from Oklahoma must be given in exchange if the library is to be built up as it should be.

CONDITIONS UNDER WHICH THE WORK HAS BEEN DONE.

While it is hoped, and believed, that the present volume will prove to be of great value and merit, the investigations necessary for producing it were made under conditions most unfavorable.

First of all, the funds were so inadequate for the amount of work required, that the task seemed almost hopeless; and it has been accomplished only by the very generous cooperation of, especially Professor C. N. Gould, head of the department of geology of the University, and of President Boyd, who did everything he could to make the work the most effective at the least possible expense to the department.

The law provides that the Professor of Biology in the University of Oklahoma, shall act as director of the department without financial remuneration of any kind.

The director has had his full work to perform as head of the department of biology in addition to his duties as Territorial Geologist. No definite amount of time is at his disposal, and the work must be done at odd hours snatched from his other duties.

The director not only receives no compensation for his work, but the personal expense connected with it is considerable; and although the correspondence is now becoming voluminous, there has never been a bill presented for postage or stationary, simply because the appropriations would not admit of the expense.

If the work is to be carried on,

LARGER APPROPRIATIONS

are absolutely essential, and the director should receive a nominal salary of $500.00 per annum, which would little more than recompense him for additional expenses incident to the work.

I quote what a few states are expending, the only figures at hand at this time:

In 1883, Indiana was spending $5,000.00 per annum; Georgia $10,000.00; New York, $25,000.00; Pennsylvania, $50,000.00; Texas, in 1891 and 1892, spent $35,000.00 per annum.

Oklahoma spent $200.00 per annum in 1899 and 1900, and $300.00 per annum in 1901 and 1902.

We do not ask for anything like such large appropriations. With $1,000.00 per annum at its disposal, the department can be made efficient, and of great value to the territory.

In order that the work of the department may be carried on efficiently, it is respectfully

RECOMMENDED:

1. That the appropriation be increased to $1,000.00 per annum.

2. That the Territorial Geologist be allowed a salary of $500.00 per annum.

3. That $2,000.00 per annum be appropriated for the next two years, for beginning , in cooperation with the United States Geological Survey, at topographical survey of the Territory.

4. That arrangements be made so that the Territorial Geologist may give a definite amount of time to the work.

5. That provision be made for an office assistant.

A. H. V.

University of Oklahoma, November 29, 1902.

GENERAL GEOLOGY OF OKLAHOMA,

BY CHARLES NEWTON GOULD.

INTRODUCTION.

Oklahoma is an irregular block cut out of the southern part of the Great Plains. Its latitude is that of Tennessee. Except in Comanche county the territory does not extend south of the thirty-fourth parallel. The northern boundary is the 37th parallel. With the exception of Beaver county, which extends in a strip thirty-five miles wide to the 103d meridian, nearly all of the territory lies between 96, 30 and 100 degrees west longitude, being in the same belt as central Kansas and Texas.

The area of the territory is 38,715 square miles, about that of the state of Ohio.

The altitude ranges from 750 feet at the point where the Arkansas flows from the territory, to nearly 4,000 feet in western Beaver county. The average altitude is approximately 1,500 feet.

SURFACE AND DRAINAGE.

The surface of the country is generally rolling. The chief topographic features are those of an old peneplain worn down to base level and afterward elevated. "Low monotonous prairies" occupy the greater part of the territory. In places one may travel for hours or even days and scarcely ascend twenty feet. In other localities, however, there are marked topographic effects. Buttes and mesas, cliffs and canyons appear and these lend to the local landscape a degree of the picturesque scarcely anticipated in a plains country.

The general slope of the country is to the southeast. All the large streams and many of the smaller ones flow in this direction. Beginning on the north the large rivers are: Arkansas, Salt Fork, Cimarron, North Canadian, South Canadian, Washita and Red. Of these the Arkansas and South Canadian alone take their rise in the Rocky mountains. The other streams rise in the high plains east of the mountains; except the Salt Fork, which in its upper course is known as the Nuscatunga, and which rises in southwest Kansas.

All of Oklahoma drains into the Mississippi. The Arkansas and Red rivers are tributary to that stream. Salt Fork, Cimarron and both Canadians are tributary to the Arkansas. The Washita flows into Red river. Besides these larger streams, the Chikaskia, Black Bear, Deep Fork and Little River are streams of considerable importance in the eastern part of the territory while farther west Cache, Deep Red, Deer, Eagle Chief and Salt and Elm fork of Red are the chief streams.

Throughout the western part of the territory the rivers parallel each other with remarkable regularity. For example, the Cimarron and North Canadian flow, on an average, twenty-five miles apart, from the point where the former first enters the territory in Beaver county to the vicinity of Guthrie, a distance of nearly two hundred miles. From Taloga to Oklahoma City, a distance of one hundred miles, the two Canadians are at no point more than 20 miles apart while in some places they approach within six miles of each other. The South Canadian and the Washita flow practically parallel for nearly two hundred miles and although there are some large bends in either stream, the average distance from one river to the other throughout this part of their course is not to exceed twenty-five miles.

In view of these facts it will be easy to understand the reason that the secondary streams throughout this region are not large. Creeks tributary to the rivers just mentioned are not usually more than ten to twenty miles in length. Several of the largest of these, Eagle Chief, Turkey, Skeleton and others are found in the level country east of the Gypsum hills between the Salt Fork and the Cimarron.

All of the larger streams, except the Washita, have broad and shallow beds, averaging perhaps a quarter of a mile wide, contained between low and sandy banks. The bed of the stream is filled with sand. Except in time of a freshet the amount of water in many of the rivers is often insignificant. A small stream, scarcely knee deep, meandering around over the sand is all that ordinarily appears. The Arkansas has periods when the bed is full for weeks at a time. The South Canadian and Red are subject to sudden rises. In these streams the bed may be dry, when suddenly a wall of water several feet high rolls down the channel sweeping everything before it. The stream remains up several days or perhaps weeks, and then gradually subsides.

The sand in all the streams mentioned partakes more or less of the nature of quicksand. Particularly after a freshet the streams are very treacherous. Many a freighter has been "stuck" in these rivers and has been obliged to abandon both team and wagon in order to save his life. Not a year passes that tragedies are not reported. Tradition has it that whole herds of cattle have disappeared in the sand of these streams.

The elevation of the various stream beds varies considerably. The Cimarron has a broad and rather deep valley, especially in the western part of the territory. The Salt Fork runs in a shallow swell in the prairie. In Western Oklahoma, there is a saying, "The North Canadian runs on a plateau; the South Canadian flows in a canyon." The level of both Canadians is considerably higher than that of the streams both north and south of them. This is shown by the fact that the divides are near the Canadians and at a considerable distance from the other streams.

An example of this fact may be cited in Oklahoma and Canadian counties, where the divide between the waters flowing into the Cimarron and those flowing into the North Canadian is very near the latter stream. Throughout the region between El Reno and Oklahoma City the divide lies close to the North Canadian. In places it is scarcely a mile distant, and no where more than four miles, while streams rising just north of the divide flow into the Cimarron thirty miles distant. Oklahoma City on the North Canadian is two hundred and seventy feet higher than Guthrie on the Cimarron. In the region of Watonga practically the same conditions obtain.

THE ROCKS BELOW THE RED-BEDS.

THE WICHITA MOUNTAINS.

The oldest rocks in Oklahoma are in the Wichita mountains in the southwestern part of the territory. These mountains are composed chiefly of three classes of igeneous rocks; garnite, gabbro and porphyry. The granite greatly predominates and composes probably nine-tenths of all the rocks of the range.

LOCATION.

The extreme length of the Wichita mountains, from the Carrolton mounds on Medicine Bluff creek at Fort Sill to the last granite hill that disappears under the high prairie five miles west of Headquarters mountain at Granite, is sixty-five miles. The extreme width from Rainy mountain to the southwestern granite butte on the North Fork of Red river six miles southeast of Navajoe, is thirty miles. The mountains consist chiefly of scattered ranges, peaks and chains. Their bases are buried beneath the surrounding and intervening plains. They may be regarded as tops of buried mountains projected above a sea of plain.

In general the mountains may be divided into two groups. The main range extends from the region of Fort Sill northwest about thirty miles to the vicinity of Saddle mountain and Mount Baker just east of the head waters of East Otter creek. This part of the range is practically continuous throughout. It is composed of rugged peaks of granite, the highest of which, Mt. Scott and Mt. Sheridan, are each about twelve hundred feet above the plain. There are two main ridges running north west and southeast separated by a valley from one to four miles wide extending nearly the entire length of the ranges. The streams draining this valley flow south and escape to the plain through gaps in the mountains. East of this main range there are a number of outlying peaks and short ranges, some of which are eight hundred feet high or more.

IGNEOUS ROCKS.

The rocks in the eastern part of the Wichitas are chiefly porphyry. This is a hard, compact rock with a grayish ground-mass containing numerous red crystals. Signal mountain, the Carrolton mounds, Medicine bluff and most of the peaks west of Fort Sill and between that place and Mount Scott are chiefly porphyry. Porphyry weathers smooth and the surface of the hills containing this rock is usually grass-covered. It is easily distinguished from the granite which weathers into large boulders. The granite hills in this region are usually covered with trees.

The high peaks of the main range, Mt. Scott, Mt. Sheridan, Mt. Baker, Saddle mountain and others, as well as the greater part of the two ranges just described are composed of red granite. This rock is cut by quite regular joint planes, and weathers into massive boulders.

In this region there are two extensive deposits of gabbro. This is a hard, black crystalline rock, sometimes known to the miners in the Wichitas as black granite. One of the gabbro deposits lies along the north slope of the north range on both sides of Medicine bluff creek. It extends northwest and southeast paralleling the range from the east end of Mt. Scott to the east slope of Saddle mountain. The exposures cover an area of perhaps two miles wide and about twelve miles long. The second gabbro locality is in the west end of the intermontane valley, along the heads of West Cache and Quanah creeks. It is some six miles long and perhaps a mile wide. The gabbro in both these localities does not as a rule present conspicuous relief but weathers into gentle slopes with occasional low ridges and buttes.

West of the main range of the Wichitas, which it must be remembered is divided into two general ridges, there are scatterel groups, peaks and low ridges extending to the vicinity of Granite, Greer county and beyond, a distance of forty miles from Mt. Baker. Some of these peaks and ranges have characteristic names. For instance, the name Raggedy mountains is applied to a group of scattered, rough outlined ridges and peaks lying along the heads of the various branches of Otter creek. Long Horn mountain is near the head of Middle Otter. Dome mountain, Tepee mountain, Elk mountain and others lie near Elk creek. Devil's Canyon mountain is six miles long and lies in a bend of the North Fork of Red river. Navajoe, Quartz and Headquarters mountains lie in Greer county west of the North Fork.

All the rocks of these mountains are granite except the central range of the Raggedy mountains which extends west from Mt. Baker fifteen miles nearly to the mouth of Elk creek. This range is composed of the black gabbro mentioned as occurring in two localities further east.

SEDIMENTARY ROCKS.

Flanking the Wichitas on the northeast and extending from a point seven miles north of Fort Sill to Rainy mountain, a distance of thirty miles to the northwest, is a row of limestone hills. These hills like the main range of the Wichitas consist of ranges, peaks and scattered knobs. The longest range is sixteen miles long and will average two miles wide.

This limestone is hard, compact and massive and is in practically all places much folded and faulted. It rarely lies level, but is cut up and tilted at all sorts of angles, more often on edge than in any other position. As one man expressed it, the limestone looks as though it had been piled up in windrows. The thickness of the formation is unknown, but it is not less than 2,000 feet, and it may be much greater. At its base there is a deposit of coarse sandstone, quartzite and conglomerate several hundred feet thick, composed chiefly of granite and porphyry grains and pebbles. The material composing this formation was evidently derived from the igneous rocks near by. In both the sandstones and the lower part of the limestones Cambrian fossils have been found. The limestones are probably part Cambrian and part Ordovician in age.

These limestone hills like the granite mountains are but the tops of buried ranges. Standing upon the top of almost any one of these hills and looking off over the sea of plain, one can, with a very slight effort of imagination, detect all sorts of sea coast phenomena. There are gulfs and peninsulas, coves and capes, isthmuses, straits and islands all petrified, as it were, but easy to distinguish. The rock comprising the plain around and between the mountains is much younger than the mountains themselves, that is, it was deposited at a much later period in the earth's history. The whole Wichita mountains with the flanking limestone hills, may be regarded as an island in the sea of plain composed of much younger rocks, which make up the greater part of the formations between the Mississippi and the Rockies. Other similar islands constitute the Arbuckles in the Chickasaw nation, the Ouachitas in the Choctaw nation and Arkansas. The high peaks of the Ozarks in Missouri and the rocks of the Central Mineral Region in Texas are examples of the same phenomena.

THE CARBONIFEROUS ROCKS.

It is proposed in the following discussion to begin with the oldest or lowest rocks in Oklahoma (exclusive of those in the Wichita region) and describe as fully as may be the succeeding formations. As has been explained the oldest rocks are in the eastern part of the territory. Farther east in the Indian Territory, Arkansas and Missouri the rocks are still older.

In general the rocks of eastern Oklahoma dip to the west or southwest. Now the country slopes to the east. In other words a line parallel to the sea level would represent the middle line of a wedge with its thin edge to the east and its back to the west, of which the slope of the country represents the upper and the dip of the rock the lower face. The rock dips from ten to twenty feet to the mile in most localities. If the surface were level a ledge that outcrops at a certain place would thus be some ten to twenty feet below the surface one mile to the west, and seventy-five feet or more deep five miles west. It is because of this fact that the following phenomenon may often be observed. A ledge appears on the eastern escarpment of a bluff. It is here the highest rock in the country. On following this ledge a few miles west other rocks come in above it and the ledge gradually finds its way lower and lower into the valley until it finally disappears under the bed of a stream. Still farther west it may be penetrated by a well, many feet under ground. In the meantime other ledges have come in above, and these in turn dip into the valley, disappear beneath the stream bed and are succeeded by others still higher. Further west the rocks lie more nearly level or may even dip slightly in other directions, but the slope of the country continues to be to the east and is even greater than in eastern Oklahoma just described.

It is this peculiarity of the combination of slope of surface and dip of rock, together with the erosion of the exposed ledges that gives the marked "stair step" structure to so much of the region. On traveling westward across the territory the hills constantly rise higher and higher. One elevation is surmounted only to encounter another ahead, and this in turn gives place to still others. Such conspicuous elevations as the Flint hills or the sandstone hills of Kansas or the Gypsum hills of Oklahoma are but somewhat exaggerated examples of this phenomena. They are more conspicuous because of local conditions of sedimentation or erosion, which have made the hills higher. They are, however, in fact no more real than scores of less marked escarpments. On passing eastward the order is reversed and instead of going upstairs one is constantly descending step after step from the western to the eastern part of the territory and even beyond.

INDIAN TERRITORY CARBONIFEROUS.

Throughout the region of the Great Plains the older rocks are to the east. As one passes westward the rocks belong to successively younger formations. As stated above the very oldest rocks on the plains are scattered groups of igneous rocks, chiefly granite, forming the heart of the Ozarks, Ouachitas, Wichitas, etc. The greater part of the Ozark and Boston mountains in Missouri and Arkansas consist chiefly of rocks older than the Carboniferous. A great part of the rocks are chiefly limestones of the Mississippian or Sub-Carboniferous. These rocks are also found in the eastern part of the Cherokee nation, I. T.

Resting upon the Mississipian is a great thickness of rocks of Carboniferous age. These rocks occupy the greater part of the Indian Territory. They constitute a part of the western coal field which extends from Iowa southwestward to Texas. This group of Carboniferous rocks occupies a considerable part of southern Iowa and northwestern Missouri; it touches Nebraska on the southeast and makes up the eastern third of Kansas. Large areas of the Carboniferous are also found in Arkansas and Texas.

The Carboniferous rocks of the Indian Territory are mainly sandstones and shales. In the northern part of the Cherokee nation there are some ledges of limestone, but even here shales predominate. Interstratified between these rocks are a number of beds of coal. These coal veins run from a few inches to as much as seven feet in thickness. The amount of coal is large, sufficient to supply the country tributary to the mines for many years to come.

The most productive coal veins are found in two general regions in the territory. The most important is known as the McAlester region from the fact that a number of the leading mines are located near the town of South McAlester. The coal veins of this region occupy a strip of country some thirty miles wide and one hundred and twenty-five miles long extending northeast and southwest from near Ft. Smith, Arkansas, to the vicinity of Coalgate and Lehigh, I. T., and beyond. In all, there are seven beds of coal in the Indian Territory which are thick enough to be worked on a commercial scale, besides others that may be worked on a commercial scale. The second region in which coal is found is in the Cherokee and Creek nations. A line of coal outcrops extends south from Kansas to the region of the Canadian river. The relation of this coal to that in the Choctaw nation is not yet well understood. Some of the principal mines in this part of the coal field are at Dawson and Henryetta.

For our knowledge of the coal fields of the Indian Territory we are indebted chiefly to the work of Mr. Joseph A. Taff of the United States Geological Survey. Mr. Taff has spent a number of years investigating this subject and has written several valuable papers describing the region. (1). N. F. Drake, Geo. I. Adams and others have also conducted investigations in the region. (2)

Not only is coal abundant in parts of the Indian Territory but considerable quantities of gas and oil are also present. At Bartlesville, Nowata, Red Fork and other localities these products have been found and it is altogether probable that further investigations will demonstrate that both gas and oil are abundant in various localities. In Kansas large quantities of these products are found in rocks of the same age and there is no geological reason why the same things should not be found in the Indian Territory.

1. See particularly "The Southwestern Coal Fields," XXII, An. Rept., U. S. G. S., pt. 3, pp. 369-412, also in XXI An. Rept.

2. A Geological reconnaissance of the coal fields of the Indian Territory, Prac. Am. Phil. Soc., Vol XXXVI, pp. 327-419, 1898.

OKLAHOMA CARBONIFEROUS.

The Carboniferous rocks extend westward into eastern Oklahoma. The line of separation between the Carboniferous formations and those of the next succeeding age, the Permian, has never been drawn. As will be shown later, it is improbable that it ever can be drawn with any degree of accuracy; at least not until a great amount of work has been done upon the rocks and a considerable number of fossils have been found. As will be shown later the Permian rocks of Oklahoma are normally red in color and consist chiefly of clays and shales, with intercolated members of sandstone, gypsum and dolomites. As stated above the Carboniferous rocks are chiefly shales, not red in color, and sandstones.

It was formerly thought that the line of separation between the Carboniferous and Permain in eastern Oklahoma might be drawn at the point of change of color in the rocks. This, however, in the light of our present knowledge, seems impracticable. The studies of Adams and others have seemingly demonstrated that ledges of limestone which in Kansas are well down in the Carboniferous rocks, pass uninterruptedly southwestward into Oklahoma. These ledges thin out to the south. At the same time the shales which in the Carboniferous have been prevailingly drab or yellowish, become more and more redish, until somewhere in the region southwest of the Arkansas river, in Payne, or Lincoln counties, Oklahoma, or in the Creek nation, the limestones disappear altogether, either changing gradually into a ledge of sandstone and conglomerate or "pinching out" and becoming red shales. From this point to the western line of Oklahoma the rocks are practically all red.

The Osage reservation occupies the northeastern part of Oklahoma, including practically all that part of the territory east of the Arkansas river. It extends about thirty-five miles east of the main part of Oklahoma. The southeastern corner of the reservation approaches within ten miles of the Dawson coal fields near Tulsa. Veins of coal are reported from various parts of the reservation and it is possible that coal in paying quantities will eventually be found there.

Throughout the eastern part of the Osage country along Buck, Sand, Bird and Hominy creeks the rocks are mostly sandstones and shales. Massive ledges from ten to fifty feet thick trend northeast and southwest across the country. These ledges extend north far into Kansas. A few ledges of heavy limestones are found. The largest of these limestone ledges disappears under Bird creek three miles east of Lewis Roger's farm, thirty-five miles southeast of Pawhuska. All of these ledges are more or less fossiliferous, and some choice specimens of Carboniferous fossils have been found in them. I know of no finer collecting ground in Oklahoma than along Bird creek in this locality.

The ledges of sandstone contained between shales and clays are found as far west as Pawhuska, the capital of the nation. Near that place limestones begin to appear. These limestones continue to the Arkansas river and beyond. These rocks are the southern extension of the famous Flint hills of Kansas. The ledges are heavy and massive and often contain considerable quantities of flint in the form of nodular concretions interstratified with the limestones. Between the limestone ledges are beds of more or less arenaceous shale or clay. In places this shale becomes quite sandy and in many places passes insensibly into thin ledges of sandstone. This is particularly true in the southern part of the Osage country and beyond on the south side of the Arkansas river.

THE LOWER PERMIAN ROCKS.

According to the classification of the Kansas geologists, notably Prosser, (3) the line of separation between the Carboniferous and Parmian has been drawn near the Cottonwood limestone. Other geologists would place this line much higher. The line of separation must perhaps finally be drawn on paleontological grounds. The cottonwood limestone is a persistent ledge containing characteristic fossils that extends from Nebraska to Oklahoma. In southern Kansas it outcrops near the summit of the Flint hills in eastern Cowley county. This would locate it in Oklahoma, somewhere near the western part of the Osage nation. The exact horizon, for Oklahoma, however, has not been determined.

While it is apparently true that the greater part of the Red-beds of Oklahoma are Permian, still it must not be imagined that all the Permian rocks are red or that all the red rocks are Permian. Further north in central and southern Kansas there is a strip of country containing Permian rocks that extends from Nebraska to the Oklahoma line and to a considerable distance into the territory, in which the rocks are chiefly gray and blue shales. This area is some two hundred miles long and averages fifty miles wide. The rocks grade upward unconformably from the Carboniferous; that is they all lie above the Cottonwood falls limestone mentioned above. In their lower part these rocks consist of more or less flinty limestones and beds of clay shales. These limestones make up the upper part of the Flint hills of southern Kansas.

To the west limestone disappears and clays and shales make up the entire series. These formations above the limestone members constitute the Marion of Prosser and the Wellington of Cragin. These two formations, however, have never been sharply outlined and it is doubtful if both names will stand.

In general the Marion and Wellington formations consist of gray, blue, drab, and yellowish shales with a few ledges of impure limestone. In places there are considerable deposits of gypsum. These gypsums may be seen in several counties in central Kansas, and in Kay county, Oklahoma. The cement mills at Mulvane, Kansas, and Peckham, Oklahoma, obtain their supply from this formation. This is also the formation in which the magnificent salt deposits in central and southern Kan-

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3. The classification of the Paleozoic Rocks of central Kansas Journal of Geology, Vol. III, No. 7, p. 795, 1895.

sas are found. The salt mined at Hutchison, Kingman, Lyons, Kanapolis and a number of other localities in the state comes from these horizons. The leaching out of this salt as the beds sloping upward approach the surface east of the deep-seated beds, forms the so-called mineral springs which are found at various points throughout the region. Geuda Springs, Kansas, are perhaps the most noted example.

These formations in the southern half of the state occupy western Cowley, Butler, and Marion counties, eastern Harvey, and practically all of Sedgwick and Sumner. The southern extension of these formations as well as the southern part of the Flint Hills extends from Kansas into Oklahoma. The Flint hills as stated above occupy the western part of the Osage reservation. The same rocks also occupy all the Kaw reservation and the eastern part of Kay, Noble, and Pawnee counties and extend into Payne county. The southern extension of the Marion and Wellington occupies western Kay county and extends into the Ponca and Otoe reservations.

In other words the Marion and Wellington formations narrow rapidly in northern Oklahoma and their place is taken by the Red-beds. Perhaps it is more correct to state that the color of the shales appears to change to the south and to become red while at the same time more of the red sandstone comes in, all tending to change the formation in lithological appearance to that of typical Red-beds. On the state line the distance from the upper limestone member to the eastern outcrop of the red rocks is perhaps thirty miles. On the southern line of Kay county, Oklahoma, it is not more than fifteen miles. Further south the line of separation can scarcely be determined. In southern Kansas there are three distinct kinds of rocks; first, the heavy limestones to the Walnut river; second, the bluish and gray clays from the Walnut to western Sumner county; and third, the typical Red-beds consisting of red sandstone and clay from this point nearly to the west line of the state.

In eastern Oklahoma, on the other hand, the conditions are quite different. In this region as stated above the limestones of the Flint hills disappear rapidly to the south. At the North Canadian it has entirely given place to other rocks. In eastern Payne country a few thin ledges of limestones remain. A section on the Twin hills seven miles east of Ingalls shows three ledges of limestone the thickest of which is not more than four feet while all the rest of the rocks are either red shales or sandstones. Above these limestones are ledges of grayish or red sandstones which thicken to the south and west and in the region between Stillwater and Orlando assume the red tint so common in the

Red-beds. All this is intended to show not only that the Red-beds extend farther east in Oklahoma than in Kansas but also that the eastern limit of the Red-beds does not coincide with the line of separation between the Carboniferous and Permian. In other words the red color of the rocks which has been thought characteristic of only the Permian of the region in fact transgresses far into Carboniferous rocks. This means of course that the line of separation between the rocks of these two ages must finally be drawn far out in the Red-beds.

Mr. Adams who has made a special study of these conditions in speaking of the problem says:

"It appears that the rocks of eastern Oklahoma which have been referred to the Red-beds on lithologic grounds, are in part of Upper Carboniferous or Coal Measure age. The sedimentation from the Carboniferous into the Permian is an unbroken sequence. From what is known of the Permian limestones of Kansas, they will be found, when followed southward, to diminish in thickness, and this change will be accompanied by a transition to more sandy beds. This is in accordance with the observations made by Mr. Gould. The age of that portion of the Red-beds which is in strike with the Permain of Kansas may confidently be expected to be found of Permian age. This is in accordance with the evidence already furnished by the vertebrate fossils. Above the Permian limestone in Kansas occur the Wellington shales, which are bluish and greenish gray in color. They are probably represented southwestward by formations which are red. The succeeding formations are typical Red-beds, and have thus far yielded only Permian fossils. Upon the accompanying map the approximate line of transition in color has been drawn with the purpose of showing that it is diagonal to the strike of the Carboniferous and Permian formations." (4).

The evidences on which these formations are separated are chiefly paleontological. Fossils, usually marine shells, are present in many of the rocks of southern Kansas. So far, opportunity for collecting in many parts of Oklahoma has not been forthcoming. Until this is done nothing definite may be accomplished in the way of classification. It is possible that data obtained upon later investigations may cause us to change our position in this matter. The statements made above, however, are believed to be fairly accurate.

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4. The Carboniferous and Permian age of the Red-beds of eastern Oklahoma from stratigraphic relations, Am. Jour. Sci., Vol. XII, Nov. 1901, p. 385-386.

THE RED-BEDS—INTRODUCTION.

The Red-beds occupy the greater part of Oklahoma. This series is by far the most important in the territory in as much as it is not only the origin of nearly all the soils but also supplies most of the building stone, gypsum, salt and other economic products. It is, however, not confined to Oklahoma but extends north and south far beyond our borders. It has excited much comment both in Kansas and Texas and considerable literature has accumulated upon the subject. No attempt has ever been made to write a description of the Red-beds as a whole. Nor is such a task contemplated in this article. It is greatly regretted that at present I have not the literature at command to even compile a complete historical sketch of the Red-beds. In this review only a few of the most prominent articles will be referred to.

The geological age of the series has long been an open question. A few years ago it was considered Triassic. Recently, however, the consensus of opinion seems to incline toward the Permian age of the rock. Until within the past year fossils had been found in but one locality in the Oklahoma Red-beds, and in Kansas none at all. The fossils found in various places by this survey during the past three years throw much light on the subject. However, until the correlation with the Texas Red-beds has been more fully worked out the final word on the subject may not be spoken. So instead of using any strictly geological term in speaking of the formation I shall employ the name "Red-beds" by which the rocks are generally known, to include the rocks of both the Carboniferous and Permian ages.

LOCATION.

The Red-beds occupy a region approximately 400 miles long and from 150 to 200 miles wide extending from near central Kansas to west-central Texas. The most northern exposure of the beds so far as known is near Arlington, a few miles south of Hutchinson, Reno county, Kansas. The extreme southwestern limit that has been recorded so far as I have been able to learn is on Kickapoo creek, Concho county, Texas, a little more than 100 miles northwest of Austin. The eastern border in Kansas and Oklahoma is a crescent shaped line extending southeast from near Hutchinson, east of Kingman, Kansas, crossing the Kansas Oklahoma line at Caldwell, then southeast near Nardin, Tonkawa and Red Rock through eastern Payne and Lincoln counties to the western part of the Seminole country. Here the line swings to the southwest and continues through the Chickasaw nation to the vicinity of Davis. It swings around the western end of the Arbuckle mountains and nearly as far east as the vicinity of Ardmore and crosses the Red River west of Gainesville, Texas. Wherever exposed so far as known the rocks along their eastern border grade upward conformably from the underlying Coal Measures.

The western limit of the Red-beds is much more irregular. In all instances so far as observed the upper line is one of unconformity. The overlying rocks range from the Lower Cretaceous to those of the latest geological formations. By far the greatest part of the upper rocks, however, belong to the Tertiary age, probably Eocene. This is the rock which covers the uplands of western Kansas, Oklahoma and Texas, and in which is found the so-called sheet water of the plains. It is also the rock in which are found the rounded, water-worn pebbles, and from which the sand of the streams of the plains is obtained. In places the Tertiary extends east along some divide nearly across the Red-beds area. In other localities it has been almost removed by subsequent erosion and the Red-beds are exposed far to the west of the main body. This is especially true along the streams where great tongues of the red rock extend many miles up the rivers, although the level uplands are covered by the Tertiary.

The principal streams crossing the Red-beds are the Salt Fork, Cimarron, North Canadian, South Canadian, Washita, Red, Brazos and Colorado rivers. These streams usually take their rise in the Tertiary to the west of the Red-beds and flow southeast across this group and pass into the Carboniferous to the east before emptying into another body of water. It is along the course of these rivers that some of the finest exposures of the Red-beds may be seen.

HISTORICAL SKETCH.

The work already done on the Red-beds has as a rule been incidental rather than particular. This statement is especially true for Kansas and Oklahoma. The work of a few earnest private investigators, one or two government reconnaissance trips, and a season or two by the University Geological Survey represent about all that has been done in the Kansas-Oklahoma region. In Texas the work has been, perhaps, more systematized, but even here it is by no means complete. In this discussion I shall review briefly such literature as has come under my personal observation in the following order: Texas, Kansas, and Oklahoma.

WORK IN TEXAS.

The first geologist to notice the Red-beds in this state was probably Professor Jules Marcou. In a paper published in 1854, he mentions

(5) Report of Explorations for a Railroad Route near the 35th parallel of latitude, Washington 1854. (6) American Geology, Zurich, 1858.

beds of red and blue clay west of the Delamare mountains. (5). These beds he assigns to the Trias. In 1858 he appears to have changed his opinion and inclines to the idea that they are of Permian age. (6). Later expolrers, notably De Ryle, Boll, Broadhead, Cope and White also referred the beds to Permian. (7).

The most extended article on the subject is by Professor F. W. Cummins. (8) The area of the Red-beds is somewhat completely outlined and the strata described under the following divisions: Wichita beds, Clear Fork beds and Double Mountain beds. Descriptions of the beds are as follows:

Wichita Beds: "The Wichita beds, which are the lowest in the series, are easly distinguished from the others by their peculiar characteristics. These beds are composed of sandstones, clay beds, and a peculiar conglomerate. There are no limestones in them from top to bottom. The sandstones are of various colors. The clays are red and bluish. They attain a thickness of about two thousand feet."

Clear Fork Beds: "The Clear Fork beds is the name given to the middle division of the Permian strata. The beds are composed of limestones, clay and shale beds and sandstones. The limestones are mostly magnesian and carbonaceous * * * and carry an abundant and characteristic fauna. The sandstones are not so abundant as in the Wichita beds, and are not so massive, but are generally thin bedded. The clays are blue and red, the red occurring in thick heavy beds. Toward the top the sandstones become more shaly and the clays more sandy. There are also some beds of gypsum, but not in such great abundance as is found in the Double Mountain Beds." The thickness is not given.

Double Mountain Beds: "These beds lie directly in contact with the Clear Fork Beds throughout the whole length, and no attempt has been made to determine a definite line of division between the two divisions. The beds are composed of sandstones, limestones, sandy shales, red and bluish clays, and thick beds of gypsum. The limestones are generally of an earthy variety, and in places have many casts of fossils, the newer types being more largely represented than those of the older. The gypsum beds are numerous and many of them thick. All the clays and shales are impregnated with gypsum and many of them carry a large per cent of common salt. The sandstones are generally very friable, and are various colors, red, white, and spotted. * * *

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(7) Second Annual Rept.. Geol. Sur. Texas, 1891, pp. 399-400.

(8). Ibid. pp. 394-424.

These beds have a thickness of about nineteen hundred feet. Toward the western extremity of the beds the red clays ar transected in every direction with seams of fibrous gypsum, making a perfect network. These seams of gypsum range in thickness from that of a sheet of paper to ten inches."

From the various beds a list of 32 invertebrates was identified by Dr. C. A. White and one of 57 vertebrates by Prof. E. D. Cope. (9). The statement is made that only the upper or Double Mountain beds are found as far north as Kansas. It was the evidence set forth in this paper that induced professor Hay to change his correlation of the Kansas beds from Triassic to Permian as will be cited in the discussion of the Kansas areas.

In a later paper Professor Cummins defines somewhat more closely the outlines of the beds and emphasizes statements already made. In discussing the Clear Fork beds he says, (4th Annual Rept. Geol. Sur. of Texas, 1893, p. 227.)

"This division probably extends northward into Kansas. It constitutes the beds along the Canadian river north of the Wichita mountains and were first reported from that locality by Prof. Marcou in 1853. This is the lowest division seen on the Canadian as the Wichita division does not occur north of the Wichita range of mountains."

Professor Cummins in this paper records the finding of Permian fossils in the upper part of the Double Mountain Beds, within 300 feet of the top of this formation. (Ibid. p. 230). It is to be regretted, however, that he does not draw clearly the line of division between the Clear Fork and the Double Mountain beds. Such a line would be of much value in correlating the Texas beds with those of Oklahoma and Kansas. Mr. Geo. I. Adams, of the U. S. G. S., is now working on this problem and it is probable that a forthcoming paper by him will do much to settle the problem.

WORK IN KANSAS.

Professor B. F. Mudge, the father of Kansas geology, in 1878 published a geological map of Kansas in which he assigned the greater part of the Red-beds area to the Carboniferous. (1st Bien. Rept. Ks. St. Bd. Agri. 2d Ed., p. 47.) St. John in his map in 1883 placed the region in the area of the Dakota Cretaceous. (3d Bien. Rept. Ks. St. Bd. Agri., pp. 575-589.) Craigin in 1885 assigned the Red-beds from Harper to

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(9). Ibid pp. 415-419.

Medicine Lodge to the Dakota and stated that the Gypsum hills are capped by the Benton. (Bull, Washburn College, Tab. Nat. Sci., Vol. I, p 86.) It was not till 1887 that St. John correlated the beds with the Triassic. (5th Bien. Rept. Ks. St. Bd. Agri., pt II, pp. 140-141.) Other writers, notably Hay, Cragin and Williston for a number of years continued to refer to the beds as belonging to this group. Both Hay and Cragin in 1889 referred the Red-beds to the Triassic (or Jurassic).

The first description of the Red-beds that was in any sense complete was published by Professor Robert Hay in 1890 as the result of a reconnaissance under the direction of the United States Geological Survey. Professor Hay in this paper discusses the series at considerable length and makes the following provisional divisions of the Red-beds:

A. Upper red rock, above gypsum plateau	100 ft.
B. Gypsum series, including the selenite seams and the massive gypsum	200 ft.
C. Lower red rock mostly without selenite seams	250 ft.
Total thickness	550 ft.

(Bulletin U. S. Geol. Sur. No. 57, p. 25.)

He also gives eight reasons and the conclusions for classifying the rocks as Triassic, as follows:

a. The formation is lithologically quite distinct from the subjacent Carboniferous strata.

b. The prevailing color of the formation is dark-red, brown, and sometimes lighter red, like the Triassic generally in Europe and America.

c. The lithified layers alternate with beds of clay and clay shale, as do the stony layers in the Triassic of the Atlantic slope and in much of the Jura-Trias of the West.

d. A massive layer of gypsum and numerous seams of selenite and satin spar appear in the formation, in which respect it corresponds with deposits farther southwest, which have been referred to the Jurassic or the Triassic on both petrographic and paleontologic grounds.

e. There are frequent shore-marks, ripple-marks and rain-drops in which the formation simulates the Triassic of the Atlantic slope and many other regions.

f. There is a marked absence of fossils, a characteristic of the Triassic generally.

g. The formation is continuous to Red river and appears to be stratigraphically connected with similar rocks beyond, which have already been referred to the Jurassic or Triassic on various grounds.

h. The surface of the formation was deeply eroded before the deposits of the Dakota or other Cretaceous were laid down.

In brief, the lithological characters, in so far as they may be regarded as criteria in the correlation of formations, and the stratigraphy alike suggest that the red rocks of southern Kansas represent the group of strata elsewhere found between the base of the Cretaceous and the top of the Carboniferous; and although the evidence is not sufficient to finally demonstrate the age of the rocks, it is sufficient to warrant the provisional application to them of the name Triassic." (Ibid, p. 25.)

These reasons, mainly negative in character, were deemed sufficient to warrant the assigning the beds to the Triassic age "until paleontological evidence shall set it aside." It will of course be understood that the Kansas beds alone were included in Professor Hay's discussion.

In the meantime fossils, both vertabrate and invertebrate had been found in the Texas Red-beds. Professor W. F. Cummins in his description of the geology of northwest Texas dicusses the relative age of the rocks of the two regions and answers the argument of Professor Hay as quoted above, in order to show that "the reasons given must give place to the paleontological evidences found in the Texan strata, and not for the purposes of controverting its application to the Kansas strata." Professor Cummins says:

"The following comments may be made upon this summary in its application to the Texas strata:

a. It is certanly different from the underlying Carboniferous, as has been shown elsewhere in this report.

b. The mere color of a rock would not distinguish between the Triassic and the Permian.

c. The lithified layers alternate with beds of clay and clay shale in the lower Red-beds of the Permian of Texas, and would go as far to prove these upper beds Permian as would conclusions drawn from Triassic rocks in another part of the United States prove those Triassic.

d. The occurrence of massive gypsum and seams of selenite does not prove anything, for the reason that they may occur in any of the strata since the Carboniferous. In Arkansas the gypsum occurs in the Trinity sands or Lower Cretaceous.

e. "There are frequent shore-marks, ripple-marks and rain-drops" in other formations than that of the Triassic.

f. This is no reason to refer strata to a distinct horizon because in other places certain strata have no fossils. But such is not the case in

Texas, because fossils have been found in all the strata I have called Permian to within a short distance of the top, and will no doubt be found there upon proper investigation.

g. The Jurassic and Triassic of Texas are not the same as the gypsum beds of Texas. The Triassic lies entirely west of the gypsums in Texas, and is so understood by Marcou and White if Dr. White concedes the fact that the Pleurophorus and other Permian fossils determine the question, which he has already done. The Red-beds referred to are those that occur in connection with the heavy beds of gypsum in Texas, and not the Red-beds of the Triassic that I have called Dockum beds."

h. The surface of the Upper Permian was deeply eroded before the Triassic was laid down in Texas, and so were the Triassic beds deeply eroded before the Blanco Canyon beds were laid down; so the question of erosion does not definitely show the strata to be either the one or the other." (Lac. Cit. pp. 421-423.)

In a paper published in 1893 Professor Hay adopts ths Permian age of the Red-beds in the following paragraph. After quoting from his former report he says: (8th Bien. Rept. Kan. St. Bd. Ag., Geology and Mineral Resources of Kansas, p. 12.)

"At the time the foregoing was written, though recognizing that the Red-beds were a continuous series with the salt measures below them, I was inclined to consider them as belonging to Mesozoic time. The absence of fossils was a strong negative feature. The Texas geologists have considered the similar beds there as of Permian age; and Professor Cope of Philadelphia, has shown me undoubted Permian fossils obtained from the Texas beds. This led me to place them in the geological scheme as Permian. Still, in the Kansas beds no fossils have yet been found."

The position here taken by Professor Hay has been accepted with greater or less reservations by most western geologists until the present time.

Professor Cragin in 1896 published a paper entitled the Permian System in Kansas in which the Red-beds are designated as the Cimarron series in distinction to the Big Blue series or Lower Permian rocks. The Cimarron series is divided into two divisions, the Salt Fork and the Kiger, and these respectively into five formations each as follows: (Colorado College Studies, Vol. VI., p. 3.)

CIMARRON SERIES.

Kiger Division: Big Basin Sandstone, Hackberry Shale, Day Creek dolomite, Red Bluff sandstones, Dog creek shales, Cave creek gypsum, Flower-pot shales.

Salt Fork Division: Cedar Hills sandstone, Salt Plains measures, Harper sandstones.

These divisions were made upon purely lithological grounds. The statement is made that the Cimarron series is from 1100 to 1250 feet thick.

The same year Professor Prosser visited the region and described at length the Red-beds areas of southern Kansas. While recognizing the divisions of Professor Cragin he says:

"This division seems to have been carried to a greater extent than the differences in the lithological characters of the rocks would justify for the rank of formation. Perhaps it is well enough to consider them as sub-formations, and group the whole mass of rocks in three formations." (University Geological Survey of Kans., Vol. II., p. 18.) "This classification may be expressed in the following table:

Upper Periam: Cimarron Series—Kiger formation; Cave Creek gypsum; Salt Fork formation." (Ibed. p. 94.)

With regard to fossils in the Red-beds Professor Prosser remarks:

"Careful search was made in the Red-beds for fossils, especially in all places where a change of color seemed to indicate a possibility of finding organic remains, but without success. This but repeats the experience of former investigators of this terrane in Kansas and judging from the known scarcity of fossils in similar formations in other regions there seems little probability of finding them in the Red-beds of southern Kansas. The great assistance that fossils would afford in determining the age of the Red-beds was fully appreciated and on this account special efforts were made toward their discovery which, however, proved fruitless." (Ibed p. 89.)

In another place Professor Prosser says:

"The writer is of the opinion that there can be no satisfactory correlation of the Kansas Red-beds" (with those of Texas) "until they have been followed across Oklahoma to Texas and the question of the Red-beds of Oklahoma settled." (Ibed. p . 92.)

Another paper by Professor Cragin was published the same year. It was written as the result of a reconnaissance in central Oklahoma and deals principally with the rocks of that territory. For this reason, although it is simply a revision of his former paper, the discussion of this article will be deferred until the literature of the Oklahoma Red-beds is reached. (American Geologist, Vol. XIX, No. 5, pp., 351-363.)

While the foregoing references represent only the most important contributions to the literature of the subject, still enough has been given to show the trend of thought and the changes of opinions regarding this series of rocks. Incidental references by such writers as Hill, Haworth, Cope, Williston, Ward, White, Beede, Vaughan and others are omitted. A perusal of all these papers will show that in Kansas the Red-beds series was first considered Upper Carboniferous, then Cretaceous, then Triassic and finally Permian. After swinging around the circle seeking for a resting place in various Paleozoic and Mesozoic groups the series finds itself about where it started from 20 years before. For this condition of affairs no one may be held accountable. The list of names given above is sufficient guarantee that the work has been well done. Some of the most noted of American geologists and collectors have visited the region, and some of them have spent weeks there. Nearly every square mile of territory consisting of half a dozen counties in south-central Kansas has been explored, and much of it repeatedly. The difficulty has always been in the absence of fossils. Careful research in hundreds of localities has so far failed to locate a single determinable fossil either vertebrate, invertebrate or plant, in the Red-beds of Kansas. This fact has been commented upon by more than one geologist. For this reason the Red-beds have come to sustain a peculiar relation to the other groups of the state. The determination of the age of this group has long been regarded as a vexing and apparently unsolvable problem.

WORK IN OKLAHOMA.

Marcy's report of the exploration of the Red river of Louisiana in 1852, contains perhaps the earliest comprehensive account of the Geology and Physical features of any considerable part of Oklahoma. This expedition started from Fort Belknap on the Brazos river in Northern Texas, crossed the Red river into what is now the southwestern part of the Indian Territory and Oklahoma. The route lay through the Wichita mountains and up the North Fork of the Red river to the head of of that stream, then southeast past the heads of other branches of the Red River to Fort Arbuckle.

Dr. George C. Shumard who was surgeon to the command made extensive collections of fossils, rocks and minerals and took copious geological notes of the region. Edward Hitchcock then president of Amherst college afterwards worked up the rocks and minerals, and Dr. Benj. F. Shumard identified the fossils. The main features of the geology were remarked, viz.: the granite peaks of the Wichita mountains, the Red-beds containing massive gypsum ledges around and west of these mountains and the marine shells of the Cretaceous, and the overlying Tertiary "drift" and sand hills. It is somewhat difficult to accurately locate all points visited by this party because of the fact that the names of most of the prominent landmarks such as creeks and mountains have been changed. (Explorations of the Red River of Louisiana in 1852; Senate Ex. Doc. 33d Congress, 1st Session, 1854.)

For a number of years little was done on the geology of Oklahoma. Some of the Texas geologists made incidental references to the subject and a few United States men published an occasional article on some phase of Oklahoma geology but no systematic work was attempted.

The published articles of Robert T. Hill and T. Wayland Vaughan have contributed somewhat to our knowledge of the formations, but these gentlemen have confined their studies chiefly to the Cretaceous and other later groups. So little was known of the Red-beds in the region that until a few years ago the Kansas Red-beds were not positively known to be continuous with those of Texas.

The most comprehensive paper that has so far appeared on the Oklahoma Red-beds is by professor F. W. Cragin, entitled "Observations on the Cimarron Series." (26.) This article is a squel to "The Permian System in Kansas" referred to above. The classification of "The Permian System" is considerably modified, a number of new terms being added and others dropped. Several of the horizons formerly classed as formations have been assigned to the rank of sub-formations, and the division between the Salt Fork and the Kiger placed above the Dog Creek instead of between the Cave Creek and Dog Creek as before.

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(26) American Geologist Vol. XIX No. 5 pp. 351-363.

The following is the new classification:

"Classification of the Rocks of the Cimarron Series.

DIVISIONS.	FORMATIONS.	SUB-FORMATIONS.
Kiger	Taloga.	Quite variable with locality.
	Day Creek.	None.
	Red Bluff.	None determined.
Salt Fork	Dog Creek (Stony Hills)	Chapman dolomite. Amphitheatre dolomite.
	Cave Creek	Shimer gipsum. Jenkins clay. Medicine Lodge gypsum.
	Glass Mountain	Flower-pot shales. Cedar Hills sandstone.
	Kingfisher	Salt plain. Harper (27).

The reasons for assigning the Red-beds to the Permian were chiefly two; first, they were supposed to be of the same geological age as the Texas Red-beds which are of Permian age, and, second, these beds grade conformably upward from the undoubted Permian in central Kansas and eastern Oklahoma. Paleontological evidence alone was wanting to confirm this classification. The work of Professor Cragin is of especial value in that he first mapped out the stratigraphical relations of a large part of the Red-beds. Whatever conclusions may be arrived at regarding the age of the rock his classification and nomenclature must remain as a testimony to his energy in first describing this very interesting series of rocks.

WORK OF THE OKLAHOMA SURVEY.

The general scheme of the work of the Oklahoma Geological and Natural History Survey has been outlined in another part of this report. In this connection it will be necessary, then, to speak only of the geological phase of the work, and that but briefly.

In the summer of 1900 a party spent eight weeks in the field. During this time the following counties were visited; Cleveland, Oklahoma, Logan, Noble, Payne, Garfield, Woods, Woodward, Dewey, Custer, Kingfisher, Blaine, Caddo, and Canadian. The work was largely of a reconnaissance nature. The main line of the Gypsum hills was touched at the Glass mountains, at bat caves in Woods county, at the Big Salt plain in Woodward county, and at the head of Salt creek and the Cedar hill in Blaine county. The second line of Gypsum hills was traced from its northern extremity to the vicinity of the Washita river and Weatherford in Custer county. All the salt plains east of the Gypsum hills were visited.

In 1902 a party spent 10 weeks in the field. The chief object of the work during this season was to locate the gypsum deposits of the territory. The route during the early part of the season lay along the main line of Gypsum hills from their southern extremity to the Kansas line. From this point the party passed south through Woodward, Day, Roger Mills and Greer counties and crossed the Red river to Texas. A week was spent in the latter state studying the relations of the Red-beds in that region to the Oklahoma Red-beds. The work during the latter part of the season lay in Comanche, Caddo, Kiowa, Washita and Custer counties. During this trip estimates were made of the amount of gypsum in the various counties. At the same time as much information as possible was secured on the subject of the manufacture of cement plaster.

Besides the two seasons of field work just mentioned the writer has made a number of special trips to practically all parts of the territory. These trips have been made with a variety of objects in view. In several instances he has had in mind the question of the water supply for a city. Again he has investigated the possibilities for oil and gas in a certain locality. Several trips have been made for the purpose of studying salt springs or gypsum deposits. On all of these special trips he has had in mind the subject of the general geology of of the territory and the observations made are incorporated in this report.

During the early part of November, 1902, the opportunity was afforded of accompanying Mr. Bailey Willis, of the U. S. Geological Survey, on a trip through the Wichita mountains and western Oklahoma. We traveled by wagon from Lawton to Granite, and from Granite north past the gypsum bluffs on the North fork of the Red river, in the extreme southeastern part of Roger Mills county, and across the sandstone comprising the upper formation of the Red-beds in Oklahoma. Another trip was made to Ferguson, Blaine county, for the purpose of studying the Gypsum hills at the head of Salt Creek. During this trip the matter of the classification of the Red-beds was fully discussed.

The classification herewith presented was worked out by the writer after the return from this trip. It embodies the result of three years work in all parts of the territory. It was sent to Mr. Willis and by him presented to the committee on geologic classification of the United States Geologic Survey, and passed upon by this committee.

The Territory of Oklahoma, that is the Territory of Red Earth, is named from the prevailing color of the rocks which extend somewhat monotonously throughout its area. With the local exceptions of the older granites and limestones of the Wichita Mountains, some limestone and shales along the Arkansas river, and the much younger deposits of sand on some of the divides between the rivers, the strata which appear at the surface all belong to what is known to geologists as the Red-beds series, which is also widely represented in Texas, in Kansas, and along the front of the Rocky Mountains to the west and north. The principal constituents of these red rocks are clays and sands, and the series in Oklahoma has a thickness which is not accurately determined, but is known to exceed 2,000 (?) feet. The series has been studied in Texas and in Kansas, and several geologists have extended their reconnaissances into Oklahoma, so that the conspicuous features have been recognized and named, and subdivisions of the series have been proposed.

Beginning with a familiarity with these previous classifications, the writer has spent three seasons in studying the Red-beds of Oklahoma, under the direction of the Territorial Geologist and in cooperation with the United States Geological Survey, and finds that there are local conditions which make it desirable to propose a somewhat different classification from any previously sugested. In so far as earlier classifications can be applied he has pursued that course, and for all divisions or members that have previously been named, and which are the same as those that he recognizes, he has used the names already given; but where new divisions have become necessary he has given new names, to avoid confusion of terms.

The principal classification previously proposed is that of Professor Cragin, (a) and the following table shows the relations of his divisions to those proposed in this report:

Cragin's Classification.		Classification Used in This Report.	
		Quartermaster Report.	
Kiger Division.	Big Basin sandstone Hackberry shales	Greer Division	Delphi dolomite. Collingsworth gypsum. Cedartop gypsum. Haystack gypsum. Kiser gypsum. Chaney gypsum.
	Day Creek dolomite Red Bluff sandstones Dog Creek shales	Woodward division	Day Creek dolomite. Red Bluff sandstones. Dog Creek shales.
	Cave Creek gypsums Flowerpot shales, upper part	Blaine division	Shimer gypsum. Altona dolomite. Medicine Lodge gypsum. Magpie dolomite. Ferguson gypsum.
Salt Fork Division.	Flowerpot shales, lower part Cedar Hills sandstones Salt Plain measures Harper sandstones	Norman division	

The term "division" is used here in a general sense, corresponding with its ordinary English meaning, to designate a larger or smaller sequence of strata which may in one instance correspond to a formation having a simple and uniform lithologic character, or in another to a group of such formations. The indefinite term "division" is preferred to the use of the word "formation," which is coming to have more definite limitations, and to the word "group," which would probably not be found appropriate for some of the simpler divisions. The classification is intentionally elastic, since the precise stratigraphic relations, which could be determined only with accurate base maps and detailed surveys, have not yet been ascertained. Nevertheless, the above-made statement of divisions and members represents all the facts now known, and affords a convenient and adequate scheme for their discussion.

(a) The Permian System in Kansas, Colorado College Studies, Vol. VI, 1896, pp. 1-48.
Observations on the Cimarron Series, American Geologist, Vol. XIX, No. 5, 1897, pp. 351-363.

THE NORMAN DIVISION.

The Norman division includes all the rocks of the Red-beds from the base of that series to the lowermost of the gypsum ledges on the eastern slope of the Gypsum hills, but neither of these limits is a stratigraphic plane; since it has been shown by Adams (b) that the base of the Red-beds is a color line extending diagonally across Carboniferous and Permian strata, and since the gypsum beds which mark the uppermost limits of the division are found to be more or less lenticular, when traced for long distances. The Norman covers a larger area than any other division of the Red-beds and is extensive in adjoining states. In Kansas it occupies parts of Sumner, Kingman, Reno, Barber, Comanche, Clark and Mead counties and all of Harper county. In Oklahoma it includes the western parts of Kay, Noble, Payne, Lincoln and Pottawatomie counties, all of Cleveland, Oklahoma, Logan, Kingfisher, Garfield and Grant, and parts of Woods, Woodward, Blaine and Canadian counties and extends into the Chickasaw nation at least to the Arbuckle mountains.

The rocks of the Norman division consist chiefly of brick-red clay shales with some interbedded ledges of red and whitish sandstone. In the eastern part of its visible extent sandstones predominate, while in the region along the base of the Gypsum hills the beds consist almost wholly of clay.

The area of the Norman division may be divided on lithological grounds into three general districts, as follows: An eastern district in which the sandstones are of sufficient thickness to form prominent ledges, a central district in which the sandstones are thinner and consequently less conspicuous, and a western district in which sandstones are practically wanting. It is not possible in the present state of our knowledge to draw lines of separation accurately between these districts, and for this reason the strata are not herein defined and named as separate formations, but a brief description of the several districts may not be out of place.

An eastern district includes all the strata, chiefly sandstones, from the eastern boundary of the Red-beds, westward about to the line of the Atchinson, Topeka and Santa Fe railroad. Topographically it corresponds practically to the southern continuation of the Flint hills of Kansas and the Osage nation, which as stated elsewhere, disappear about the line of the Arkansas river. Or perhaps it would be more correct to say that the rocks of this district are in strike with those of the Flint hills. This subject has been worked out by Adams and is discussed elsewhere.

Am. Jour. Sci., Vol. XII, pp. 385-386.

In general the rocks of this district consist of alternating strata of red and whitish sandstone and red clay shale. Along the streams the sandstones often outcrop as ledges twenty or more feet thick. To the east of the Santa Fe railroad the sandstone beds are most abundant, but they are grayish or even almost white, though the intervening clay is always red. Business blocks at Perry, Orlando, Mulhall, Guthrie, Edmond, Oklahoma City, Norman and Noble along the line of the Santa Fe railroad are built of the red sandstone. The buildings of the Oklahoma Agricultural and Mechanical College at Stillwater, and many of the business blocks of Shawnee are constructed of the lighter colored stone. Practically all the towns of Lincoln, Payne and Pottawatomie counties and those in the eastern parts of Noble, Logan, Oklahoma and Cleveland counties contain buildings constructed of either the red or the gray sandstone. Through the entire region it is used for the abutments of bridges, for corrals and small buildings and not infrequently for dwelling houses.

The sandstone is water bearing. Springs are not uncommon, and water which is ordinarily soft and suitable for all domestic purposes is usually found in wells at moderate depths. It is the best water found anywhere in the Red-beds below the Quartermaster division.

The region is well wooded. Trees grow along the streams and in many places on the hills. The three eastern counties especially, are covered with a considerable growth of the more hardy forest trees, notably oak and hickory. Along the line of the Santa Fe railroad the uplands are level prairie and the bottom lands are timbered. West of this line the timber becomes less plentiful.

West of the sandstone district is a triangular area occupying half a dozen counties in the central part of the Territory, in which there is but little hard rock of any kind. This is the great wheat belt of Oklahoma. A line from Blackwell to Norman would approximate its eastern boundary and one from Alva to El Reno its western limit. It includes eastern Blaine, Canadian and Woods counties, all of Grant, Garfield, and Kingfisher, and the western parts of Kay, Noble, Logan, Oklahoma and Cleveland counties.

Throughout this area the soil is red, except where later deposits cover the uplands, or among the sand hills north of some of the streams. Red clays and occasional ledges of thin sandstone outcrop along the bluffs of a few streams. These sandstone ledges, however, are of comparatively little economic value, being generally too soft for building purposes, but when one is hard enough to be used in this way it may afford a larger income than a quarter section of good land.

Such quarries occur near Nardin, Kingfisher, Hennessey and Luella. In the general absence of building stone foundations for houses are usually made of brick, and artificial stone may come into use extensively.

The rocks of the western district of the Norman consist chiefly of red clay shale, some inconspicuous ledges of soft sandstone, and occasional bands of whitish or greenish shale, which varies from one inch to several feet in thickness. The upper strata are in places extremely gypsiferous and in some localities brine springs issue from these rocks. No attempt is made to draw a definite line of separation between the central and western districts of the Norman division except to state that in general, such a line may be disintinguished a few miles east of the base of the Gypsum hills.

The rocks of the central and western districts of the Norman are in most places strongly impregnated with mineral salts, particularly common salt and gypsum. In many localities the water from the wells is unfit for drinking and the people are obliged to use cistern water.

In the northwestern part of the central district, and twenty miles or more from its western limit, in northeastern Woods county, is the Salt plain of the Salt Fork river, one of four extensive salt plains in Oklahoma, which outcrop below the heavy gypsum ledges. The Salt Fork plain, being at a considerable distance from the Gypsum hills, differs from others, which are all situated in the immediate vicinity of the gypsum outcrops and usually in canyons below massive ledges of that rock. The Salt Fork plain is from ten to twelve miles in length from north to south and averages seven miles in width. The area covered is more than seventy-five square miles and it is the largest in the Territory.

It is in the western district, however, along the base of the Gypsum hills that the salt measures seem most abundant. Salt springs give rise to a group of salt plains all of which are on the Cimarron or its tributaries. The Little Salt plain in northern Woodward county near the Kansas line, and the Big Salt plain in the northeastern part of the same county, are both located in the Cimarron river channel, while the Salt Creek plain in north-central Blaine county is on a tributary of this river.

It is at the Salt Creek plain that some of the most typical salt springs may be seen. In several canyons at the head of Salt Creek there are exposures of a grayish-red, mottled, saliferous sandstone, often distinctly cross-bedded, from which issue numerous springs of strong brine. So far as known this sandstone is not seen elsewhere in the region, and it seems to be a local phase of the clay shale formation. It is possible, however, that these sandstones are not in themselves salt bearing, but that they are merely porous strata through which brines from some deep-seated source reach the surface. The water from the springs issuing from the various canyons, forms rills, which, uniting, form the head waters of Salt creek.

Above the level of the salt plains and below the gypsum ledges there intervene some 150 or 200 feet of red clay shale which is interspersed with bands of white and bluish clay and local ledges of thin gypsum. The very soft material of which this shale is composed renders it particularly susceptible to the action of weathering and the entire thickness is characterized by marked erosion forms. Wherever the cap of gypsum has been removed over any considerable area, or for any great length of time, these shales have been worn away. Perhaps the most common erosion form is that of cones of red clay cut by deep and uneven gullies,—regular Bad Lands structure. Not infrequently rows of these cones are arranged palisade-like along the summit of a fast disappearing ridge into which gullies are eating their way.

The face of the bluffs below the gypsum ledges is frequently covered with fragments of gypsum, either in the form of plates of transparent selenite or of globular masses. The selenite is usually found in seams running diagonally through the clay, and the crystals, weathering out on the slopes reflect the sun from thousands of points, giving an appearance as if covered with glass. This fact has given the name Glass Mountains to a part of the Gypsum hills.

The thickness of the Norman is unknown, but it is certainly not less than 1200 feet. A well at El Reno begun at about the same level as the top of this division reached a depth of 1326 feet and the drill stopped in red clay.

Nomenclature. The name Norman as used in this connection is that of the county seat of Cleveland county and is applied to all rocks which professor Cragin described in his first paper under the names, Harper, Salt Plain, Cedar Hills, and the greater part of the Flower Pot. The upper part of his Flower Pot is hereafter included in the lower part of the next higher division, the Blaine. In Professor Cragin's second paper he includes the Norman division in the Kingfisher, and Glass Mountain formations. The division also includes the sandstones of the eastern district that professor Cragin never visited. It is believed that in the present state of our knowledge the available data are not sufficient to define formations or members within the division.

THE BLAINE DIVISION.

The Blaine division consists of red shales with interbedded strata of gypsum and dolomite. The characteristic which justifies its recognition as a division is the abundance of gypsum contained in it and its extent and limits are defined accordingly. The base is the bottom of the lowest massive gypsum bed, named the Ferguson gypsum member, so far as it extends northwest from Darlington, Canadian county. Where it disappears the shales of the Norman continue up to the base of the Medicine Lodge gypsum, and it necessarily becomes the basal member of the Blaine division. The top is the Shimer gypsum member. Where the gypsum members run out as they all do in the region north of Darlington, the Blaine can not be distinguished readily from the Norman below and the Woodward above, and this local division of the Red-beds can not be well traced. The Blaine division gives rise to an escarpment known as the Gypsum hills, extending from Darlington northwestward between the North Canadian and the Cimarron rivers, through the corner of Kingfisher counties, across Blaine and into Woods. At the Glass mountains the escarpment approaches closely the Cimarron to which it extends parallel northwesterly to the Kansas boundary. Crossing under the bed of the Cimarron river, the strata forming the escarpment swing east through northeastern Woodward county, cross the northwestern corner of Woods, and pass into Barber county, Kansas, where they trend north and northwest and finally disappear under Teritiary sands north of the Medicine river, 30 miles northwest of Medicine Lodge.

The Blaine division consists of five members, three ledges of massive gypsum, and two of more or less arenaceous and argillaceous dolomite, interstratified with red shale. The several members of the Blaine may be briefly described as follows:

Ferguson Gypsum. The Ferguson gypsum member is the lowermost of the heavy gypsum ledges in the Redbeds of this region. It varies in color from almost pure white to a dirty brown according to the purity of the rock. It outcrops as a conspicuous ledge, usually a little more than half way up the slope of the escarpment maintained by the division, and is in many places the most prominent of the three gypsum ledges. In Canadian, Kingfisher and southern Blaine counties it is also the thickest, but it thins out to the north and disappears in the region of the Glass mountains, north of which only the two upper gypsum ledges appear. The name is that of the town of Ferguson, Blaine county, in the hills southwest of which the ledge is typically exposed.

Magpie Dolomite. Above the Ferguson is a stratum of red shale. Upon this in its turn rests a ledge of arenaceous dolomite which usually varies in thickness from one to three feet, but in places, as on West creek, Woods county, thickens locally to ten or twelve feet. It contains fossils. This dolomite lies at the base of the second gypsum member and is often thoroughly concealed, but its hardness and arenaceous character render it less easily eroded than the gypsum and it often remains as the cap rock upon buttes and shoulders from which the overlying gypsum bed has been removed. The name Magpie is from the permanent camp of an Arapahoe chief of that name on Bitter creek, Blaine county, just below the ledge.

Medicine Lodge Gypsum. The Medicine Lodge gypsum rests upor the Magpie and in many places completely covers it. It is perhaps the most conspicuous gypsum ledge in the Red-beds. It extends uninterruptedly from near the head of the Medicine river in Kansas, to Canadian county, Oklahoma, and is in most places the ledge which forms the cap of the Gypsum hills. No better description of this ledge can perhaps be given than that of professor Cragin who first described this ledge in Kansas as follows: (c).

"In minor parts, the Medicine Lodge gypsum is nearly pure white; in others it is suffused with leaden-gray or dusky-brown shades; most commonly it is grayish-white mottled with feebly defined dark spots. The latter are generally the expression of a tendency that existed in the gypsum, under the original conditions of precepitation to form crystals, as is shown by the occurrence of spots in every gradation from ill-defined spot-like seggregations to well-formed crystals of selenite. Some of the crystals are of the common rhomboidal pattern, others are of the stellar type."

The name Medicine Lodge is that of the county seat of Barber county, Kansas, and was proposed by professor Cragin in 1896.

Altona Dolomite. The Altona dolomite is the next notable member above the Medicine Lodge gypsum from which it is separated by a stratum of shale,—the Jenkins clay of Cragin. It is an arenaceous dolomite which differs neither in lithological character, areal extent or relation to the superjacent gypsum from the Magpie. Both of these dolomites are fossiliferous, and so far as known they are the only fossiliferous ledges in this part of the Redbeds. In the eastern part of Blaine county the Gypsum hills are known locally as the Stony hills, because of the fact that the rock from the Magpie and Altona, being harder than other rocks in the vicinity, weathers out and in places covers the slopes of the hills. This stone is hauled for considerable

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(C) Op. Cit. p. 32.

distances across the plains to the east for building purposes. The name Altona is that of a postoffice in the southwestern part of Kingfisher county, southwest of which the dolomite is well exposed.

Shimer Gypsum. Resting upon the Altona dolomite is a third gypsum ledge to which professor Cragin gave the name Shimer gypsum from a township in Barber county Kansas where the rock was first studied. It is the uppermost member of the Blaine division and is typically exposed either as the highest ledge outcropping somewhat back from the brow of the hills, or as the cap rock of occasional bluffs and buttes overlooking the slopes below. The description of the Medicine Lodge gypsum quoted above from professor Cragin, will in most places apply equally well to the Shimer, but the thickness of the upper ledge is not so great as that of the Medicine Lodge. Its areal extent and physicial characters are practically identical.

The thickness of the Blaine division varies considerably with the locality. An average thickness will approximate 75 feet.

Nomenclature. The Blaine division is named from Blaine county, Oklahoma, where the various members are typically developed. The division includes as much of professor Cragin's Flower Pot formation as lies above the base of the Ferguson gypsum, and all of his Cave Creek formation.

THE WOODWARD DIVISION.

Above the Blaine there is a thickness of approximately three hundred feet of rocks, consisting chiefly of shales, sandstones and dolomites, and distinguished from the divisions above and below by the prominence of dolomites and the absence of gypsums. The division includes all the rocks between the two conspicuous gypsum horizons, the Blaine and the Greer, and in general it may be divided into three members, the Dog Creek, the Red Bluff, and the Day Creek, which were all recognized and named by professor Cragin from localities in Kansas. For the division as a whole from the top of the Shimer gypsum to the base of the Chaney gypsum the name Woodward is proposed from the county in Oklahoma where the strata are well represented.

Dog Creek Shales. The Dog Creek member is composed mainly of clays containing occasional thin ledges of magnesian limestone which in places grade into a fair quality of dolomite. The ledges, however, are usually thin and are rarely sufficiently conspicuous to be worthy of more than passing notice. Professor Cragin's original description of this member is as follows:

Op. Cit. p. 39.

"The Dog Creek * * consists of some thirty feet, or locally of a less or greater thickness, of dull-red argillaceous shales, with laminae in the basal part and one or two ledges of unevenly lithified dolomite in the upper. The color of these shales resembles that which prevailes in most of the divisions below rather than of the terranes above the Dog Creek."

In his second paper he modifies his description in this way: (e.)

"In central Oklahoma it is a great dolomite formation, laminated dolomite occupying a considerable part of the thickness."

In this second paper he attempts to change the name Dog Creek to Stony Hills. The writer agrees that the name Dog Creek is perhaps not the best that could be used, but in view of the fact as shown above, that the dolomites that make up the Stony hills in eastern Blaine county belong to the Blaine division and do not belong to the Dog Creek, there seems to be no legitimate reason for using the name Stony Hills to designate this member.

Studies made during the past three years have demonstrated that in many parts of Oklahoma the thickness of the Dog Creek is much greater than that given by Professor Cragin. Near Quinlan, in eastern Woodward county, the aneroid gave 225 feet as the thickness of these beds, measured from the top of the underlying gypsums of the Blaine division to the sandstones of the next higher member the Red Bluff, and in a number of localities 150 and 175 feet were recorded as the thickness of this member. Exposures are common along the top of the Gypsum hills from Canadian county to the Kansas line and beyond.

Op. Cit. pp. 40, 41.

Red Bluff Sandstone. The Red Bluff sandstone was also named and described by professor Cragin as follows.

"This formation consists of some 175 or 200 feet of light-red sandstones and shales. * * Viewed as a whole it is very irregularly stratified, being in some cases considerably inclined, in others curved and this oblique and irregular bedding, being on a much larger scale than that of ordinary cross beddings, at first glance gives the impression of dips, anticlines, synclines, etc., that have been produced by lateral pressure, the dips being, however, in various directions. * * The Red Bluff beds exhibit the most intense coloration of any of the rocks of this series. When the outcrops are wet with recent rains their vividness of color is still greater, and the contrasts of their almost vermillion redness with other colors of the landscape is most striking Spots and streaks of bluish or greenish-gray sometimes occur in these

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(E) Op. Cit. p. 358.

rocks but not to nearly so great an extent as in the lower beds. The sandstones of the Red Bluff are generally too friable for building stone but in some instances selected portions have proved hard enough for such use and are fairly durable."

In Oklahoma the Red Bluff often weathers into conspicuous buttes and mesas. For instance in eastern Woodward and western Woods counties a row of these buttes, which rise from 100 to 200 feet above the surrounding country, extend from the vicinity of Whitehorse spring, southwest across the Cimarron and to the high divide beyond. To some of these buttes characteristic names have been given as Lone butte, Potato hill, Watersign hill, Wild Cat butte and the like. The noted Red hill between Watonga and Geary in southern Blaine county is composed chiefly of the Red Bluff, while south of the South Canadian river this sandstone thickens and forms conspicuous buttes southwest of Bridgeport,—the famous Cado county buttes. The Red Bluff is exposed along the Washita from near Chickasha westward and in the region of Anadarko it forms bold bluffs both north and south of the river, and extends as far west as Mountain View. Ledges which belong to the same general horizon outcrop along the northern flank of the Wichita mountains in the region about Harrison and Hobart, and it is altogether possible that further studies may demonstrate that these beds follow under the upper gypsums across Greer county.

Day Creek Dolomite. Capping the Red Bluff in Kansas and Oklahoma is a conspicuous ledge of hard dolomite first described by Professor Cragin as follows: (g.)

"Upon the latest of the Red Bluff rests a persistent stratum of dolomite, varying in thickness from less than a foot to five feet or more. * * It is a true dolomite, containing with the carbonate of lime an equal or even greater percentage of the carbonate of magnesia. * * Though not of great thickness it is an important member of the upper Permian of southern Kansas and northern Oklahoma owing to its persistence which makes it a convenient horizon of reference. * * The stone is nearly white in fresh fracture, weathering gray, and often has a streaked and gnarly grain resembling that of fossil wood. * * Its cherty hardness and fracture are not due to the presence of silica as one is tempted to infer, but are characters belonging to it as a dolomite. It is a durable building stone."

In his second paper in describing a typical Oklahoma locality he says:

Op. Cit. p. 361.
(G) Op. Cit. p. 44.

"The brow of the Red hills near Watonga, Oklahoma, is capped wi the Day Creek dolomite, which here presents itself as a compa stratum of gray, somewhat pinkish or reddish-tinged, cherty-hard roc little different from the typical ledge that skirts the flanks of Mou Lookout in Clark county, Kansas. The stratum has a thickness of thr feet."

The line of outcrops of the Day Creek in Oklahoma is not contin ous, nevertheless it is found in numerous localities, and always at t same general horizon. It is displayed on many of the hills of Woo ward county not only north of the Cimarron, but between the Cimarro and the North Canadian, and also south of the latter stream. In Blai county it forms the caps of a number of the prominent hills, notably t Red hills between Watonga and Geary mentioned above. South of t South Canadian in Caddo county the dolimite covers the Red Bluff bu tes southwest of Bridgeport, and outcrops southwestward to the hea waters of Cobb creek and on the west side of that stream past Colony. I the vicinity of Mountain View in the valley of the Washita river a led of dolomite appears at the same general horizon as that occupied by t Day Creek. In the hills north of Harrison and Hobart there is also ledge of dolomite which may provisionally be referred to this horizon.

Nomenclature. As stated above the names Dog Creek, Red Blu and Day Creek were originally used by professor Cragin and they a here applied to precisely the same strata in each case as those whi he designated. They may be considered members of the Woodwa division or formation, or formations of the Woodward group, witho in any way altering their individual stratigraphic values, but the ter members appears better to express their relations as parts of a divisio which is characterized throughout by the presence of dolomite occurin in more or less frequent beds.

THE GREER DIVISION.

Succeeding the Woodward division is a thickness of from 150 t 300 feet of rocks consisting of red clays, shales, and sandstones wi intercalated beds of gypsum and magnesian limestone or dolomit Gypsum is the characteristic deposit of this division as it is of t Blaine. The rocks of this division, for which the name Greer is pr posed, from the county in southwestern Oklahoma in which they a well exhibited, are exposed over a very irregular area. For purpos of discussion they may be grouped according to two general distric an eastern and a western. The eastern district extends from the sout ern part of Woodward county southeast through Dewey, Custer, Was ita, Caddo and Comanche counties into the Chickasaw nation. The western division spreads out over Washita county, touches the extreme southeastern part of Roger Mills and crosses Greer county to Collingsworth county, Texas. The rocks of the two districts are covered above by the same formation.

The rocks of the eastern district of the Greer division strike northwest and southeast just west of the outcrops of the Woodward. The rocks are chiefly red clay shale, interstratified at several horizons with red sandstone and gypsums, which are, however, very irregularly bedded and cannot be traced as continuous or definite ledges. Nevertheless the thickest ledges of gypsum known in the Red-beds are found in this district. Thus five miles northwest of Weatherford a ledge 60 feet thick was measured, in the vicinity of Cloud Chief beds 50 feet thick are not uncommon, and in a well near Segar, Washita county, one 115 feet thick is reported. But these beds are not constant, appearing and disappearing without apparent regularity. Along a single bluff one may see a ledge changing from gypsum to sandstone within a distance of a few rods, and a quarter of a mile further the sandstone may again pass into gypsum. So very erratic is the stratification of all the rocks of the Greer division in this district that no attempt is made to divide it into members. A section made at any particular locality would usually not answer for a point half a mile away.

The most northern outcrop of the rocks of this division so far as known is in the southeastern part of Woodward county, Oklahoma, a few miles south of Richmond. It is possible that these strata represent the southern continuance of Professor Cragin's Hackberry Shales and Big Basin sandstone, but further study in the field is necessary to substantiate this point. A few miles south of Richmond, Woodward county, on the divide between the North and South Canadians, a thin ledge of gypsum interstratified between shales and sandstones appears. This ledge, which is from one to three feet thick, continues south, appears as a cap to the high bluffs along the South Canadian north and west of Taloga, and outcrops on both sides of this river as far as the vicinity of Stone, Day county. The ledge thickens to the south and is reinforced by others until at Weatherford, Custer county, one of the beds is more than 60 feet thick. The various ledges averaging perhaps ten feet in thickness, outcrop along the various .branches of Barnitz creek and the Washita river in Custer county and as far west as Roger Mills county. In eastern Washita county in the vicinity of Segar, in the region between Cloud Chief and Weatherford, the gypsums seem to find their extreme development, there being several heavy ledges, and one, as stated above, that has a reported thickness of 115 feet.

The strike of the rocks continues to the southeast and outcrops occur on the hills north of the Washita river, between that river and Cobb creek, almost to Ft. Cobb. South of that river the gypsum forms conspicuous ledges opposite Ft. Cobb, and on the hills to the south and east. Ledges continue to be seen on the divide between the waters of the Washita and those of Red river as far as the vicinity of the Keechi hills in southwestern Caddo county, and between these hills and Apache. The same beds probably extend to the region of Marlow, I. T.

The western district of the Greer division differs in several particulars from the occurrence in the eastern district, just described. The rocks instead of being erratically stratified are deposited in regular layers. Sandstones are practically absent, or at least inconspicuous, and the sequence consists of ledges of gypsum and magnesian limestone interstratified between gypsiferous clays.

The rocks of this district appear to connect with those of the eastern district in southeastern Washita county, although throughout the region between Cloud Chief and the southwestern part of the county across the valleys of the various branches of Elk Creek, the gypsums do not ordinarily appear. But at several points, along the line of strike ledges ten feet or more in thickness may be seen in canyons or along stream beds. Just before reaching the North Fork of Red river, and just north of the corner of the three counties, Roger Mills, Washita and Kiowa, regular ledges appear. Along the north side of North Fork for ten miles or more these gypsum ledges form the escarpment of a bluff from 125 to 175 feet high. Of this height the gypsum members, her exposed in four separate ledges, constitute 75 feet, perhaps the fines exposure of gypsum in Oklahoma. The river cuts through the formation west of these bluffs and the gypsums again appear at Haystack butte in Greer county some twenty miles northwest of Granite. Th rocks of the Greer form conspicuous bluffs on both sides of Haystack creek and on Elm Fork of Red river and its tributaries as far as Collingsworth county, Texas. The gypsums which occur in such abundanc in southern Greer county in the vicinity of Duke and El Dorado are no positively known to belong to the Greer formation.

As stated above, the rocks of the western district of the Greer consists of red clay-shales, heavy ledges of gypsum and a ledge of dolomit or magnesian limestone. At the base of this division is an unknown thickness of red gypsiferous and saliferous shales and sandstones These shales contain occasional local ledges of gypsum a foot or two fee thick, and bands of white and greenish shales are not uncommon. In the region of the heavy gypsum ledges there are several salt plain fed by springs that issue from below the gypsums, or in one instance, from shales between the gypsums. These intervening shales contained between the gypsum beds do not differ materially from those at the base of the division, nor from the shale beds between the gypsum ledges of the Blaine division. Immediately beneath the heavy gypsum beds there is often a foot or two of bluish or greenish clay or shale.

The most prominent gypsum ledges outcropping in this district of the Greer division are five in number, the three upper ones being thickest and most conspicuous. In general, neither of the two lower ledges is more than four feet thick, and because of their position near the foot of the bluff they are frequently so inconspicuous as to escape notice. The description of the various members is as follows:

Chaney Gypsum. This gypsum is well exposed along the south side of Elm Fork from Mangum northwest to the Texas line. It is also seen in Haystack creek, but on North Fork, in Roger Mills county it loses its characteristic structure and becomes simply a gypsiferous band in the red clay. On Elm Fork the mouth of Hackberry creek and also at the Kiser and Chaney salt plains near the Texas line, it is a hard, massive stratum 3 to 5 feet thick usually white but sometimes gray or bluish. It is often distinctly stratified or apparently cross bedded, or it may be that the lines of stratification are waving. The name is from the Chaney salt plain on Elm Fork of Red River, four miles east of the Texas line.

Kiser Gypsum. This member is exposed throughout the western district of the Greer division. In appearance it is rarely white and in this regard differs from all the other ledges in this division. In colcrs it varies from a decidely bluish or greenish tint to drab or gray. On the North Fork it was described in the author's field notes as "greenish gypsum and gypsiferous shales, becoming hard locally," and on Haystack creek as "bluish and drab gypsum grading into gypsiferous rock and clay." On Elm Fork at both Kiser's and Chaney's salt plain it is a soft, bluish to greenish, selenitic gypsum, and at the mouth of Hackberry ten miles down Elm Fork it is recorded as a bluish stratified gypsum. These descriptions are mentioned to show that while the general character are fairly constant, still the stratum varies considerably in local sections. The soft character of the rock renders it particularly susceptible to weathering and it is frequently inconspicuous. Its thickness varies from one to three feet. The name is from the Kiser salt plain on Elm Fork, Greer county, where the ledge is well exposed.

Haystack Gypsum. The upper part of the Greer consists of three ledges of massive gypsum and one ledge of dolomite, interstratified between ledges of red clay shale. The lowermost of the three thicker ledges, the third ledge from the bottom of the division—consists of the typical massive gypsum, almost pure white or occasionally grayish in places, with a few thin bands of gypsiferous sandstone. This ledge is often cut by joints, which separate the rock into rectangular blocks. These blocks frequently weather out and roll down the slope, and in places render it conspicuously white for miles. The thickness of the Haystack varies locally from 18 to 25 feet, and so far as known, it is the thickest ledge in the western division of the Greer. It is exposed along all the bluffs on North Fork and Elm Fork and is particularly conspicuous on Haystack creek and in the vicinity of Haystack butte, whence the name.

Cedartop Gypsum. The Cedartop is a massive, white gypsum very similar in appearance to the Haystack. Its thickness is very constant throughout the region of outcrop, being from 18 to 20 feet where ever measured. It is very conspicuous on North Fork, Haystack and Elm Fork, forming the caps of a number of buttes and bluffs throughout the region. The name Cedartop is from a prominent butte of the same name on the North Fork of Red River in the extreme southeastern corner of Roger Mills county. This rock forms the upper ledge of this butte and may be seen from a great distance up and down the river and even from Headquarters mountain at Granite, fifteen miles south.

Collingsworth Gypsum. This is the upper gypsum ledge of the Greer and it does not differ materially in lithological appearance from the Haystack or Cedartop. Like them it is massive and white throughout, and like them also it is cut by a series of master joints into rectangular blocks. Where exposed the thickness varies from 18 to 20 feet, being thicker than the Cedartop and not so thick as the Haystack. Being the upper gypsum member it has often been eroded and for that reason does not always appear in a section. Near the heads of the various creeks, however, it is the most prominent ledge, and it is also exposed on a number of the prominent bluffs as for instance along the bluff on North Fork. The name is from Collingsworth county, Texas, just west of Greer county, Oklahoma, where the gypsum is well exposed.

Delphi Dolomite. Above the Collingsworth and separated from it by some 20 feet of red clay shale ,is a very persistent 3 foot ledge of more or less dolomitic limestone. In places it is true dolomite while again it contains only a smaller per cent of magnesia and is nothing but a magnesian limestone. The character of the rock varies considerably. In places it is arenaceous and soft; in other localities cavernous, or perhaps honeycombed in structure. Often, however, it is firm and solid and forms an excellent building stone. Its color is white, drab, gray, or sometimes yellowish. The underlying clays have often been eroded and the rock frequently covers slopes at a considerable distance below its original position. While three feet is an average thickness for the ledge it is sometimes not more than a foot thick, while in other places it is as much as five feet thick. It is exposed on the hills north of North Fork in Roger Mills county, and on practically all the divides of Elm Fork and Haystack, Bull and Fish creeks in Greer county. The name is from the town of Delphi, Greer county, on the slope south of which there are exposures of the dolomite.

THE QUARTERMASTER DIVISION.

Succeeding the Greer division is a thickness of three hundred feet or more of rocks consisting for the most part of soft red sandstones and arenaceous clays and shales. So far as known, this is the highest formation of the Red-beds in Oklahoma.

In the lower part of the division the rocks are chiefly shales, typically red, but sometimes containing greenish bands and layers. The shales become more arenaceous above and in places form a strongly consolidated sandstone, which is rather thin bedded and prone to break into small, rectangular blocks, and weathering queerly into long and narrow buttresses or rounded, conical or nipple shaped mounds from ten to fifty or more feet high. These mounds may be solitary, or occasionally hundreds of them will be seen on a single quarter section. The sandstone is further characterized by the marked and very peculiar dip of the rocks in certain directions. Strata may often be noticed dipping at an angle of from 20 to 40 degrees, nor is the direction of the dip regular, but varies to all points of the compass even in a small area. These dips often produce escarpments that have the appearance of those formed by regularly-bedded dipping strata. The most plausible explanation of this phenomena is that the erratic dipping is caused by the undermining of deep-seated rocks, probably some of the various gypsum members of the Greer.

In this sandstone, particularly in its upper part there are many springs of soft water, which usually issue as seeps at the head of a deep canyon, or beneath a bluff of red sandstone. While few of them flow a large amount of water, still many of them are sufficient to supply a farm house, or in some cases to furnish stock water for a ranch. Wells in these sandstones frequently find good water at moderate depths. With the exception of the eastern district of the Norman, the Quartermaster is the only division in the Red-beds in which any considerable amount of good water is found.

Except where covered by rocks of more recent geological age, the Quartermaster includes practically all the rocks exposed in Day and Roger Mills Counties, and is also well developed in the western part of Dewey, Custer, and Washita counties. It is underlaid by the Greer to the east and south, and to the west and north disappears beneath the sands of the Tertiary. Streams tributary to the South Canadian, Washita, and the North Fork of Red River in the region, form canyons in this rock and are fed by springs issuing from it. The name is from Quartermaster creek which flows from Day county through the extreme northwestern corner of Roger Mills and empties into the Washita river in Washita county. Along this creek both the lower shales and the sandstones higher up in the formation are well exposed. The peculiarities of structure and weathering are also well exemplified along this stream.

In the present state of our knowledge it is not deemed advisable to attempt to subdivide the Quartermaster's division.

PALAEONTOLOGY OF THE OKLAHOMA RED-BEDS.

The scarcity of fossils in the Kansas-Oklahoma Red-beds has been a matter of comment ever since these rocks have been studied. In Kansas, particularly, such collectors as Hay, Cragin, Prosser, Beede, Williston and others have at various times searched carefully over the half dozen counties in which these rocks are exposed, but without avail. So far as known not a single fossil has ever been found in the Kansas Red-beds.

In Oklahoma, fortunately, the results have been more satisfactory. Not that fossils are abundant, for they are in fact very rare. Still, enough forms have been found at various horizons to assist the geologist in the classification of the rocks. Three years ago the geological age of the Red-beds was not certainly known. At that time fossils had been found in but one locality, and these were far from satisfactory for purposes of correlation. Since that time, however, three additional localities have been discovered. Two of the four Oklahoma localities have yielded only invertebrates; in one locality vertebrates alone have been found, and in the fourth locality vertebrates, invertebrates and plants have been secured. A brief description of these localities and the fossils obtained from each will be given.

THE NARDIN LOCALITY.

In 1897 fossils were found by the writer in the McCann stone quarry on Deer creek, 5 miles southeast of Nardin, and 12 miles southwest of Blackwell, Oklahoma. The fossils are contained in a ledge of sandstone, two to five feet thick, that lies at the base of the Red-beds. (32) Its geological position seems to be at the top of the Wellington and between that formation and the Norman, the basal member of the Red-beds as known in Oklahoma. Besides numerous scales, broken teeth and fragments of bone, a number of almost complete single vetebra have been found and several complete bones of a large vertebrate animal. A number of invertebrates and several poorly preserved leaves were also secured. Dr. S. W. Williston identified the vertebrate as a species of Eryops, a Permian amphibian, described by Cope from the Texas beds. (33.) * The invertebrates were identified by T. Rupert Jones as a species of crustacean, Estheria minuta, a form most common in the Triassic. (34.) * With regard to this Dr. Lester F. Ward expressed the opinion that, while the specimens were too poorly preserved for accurate identification, they appeared to represent Mesozoic forms.

THE ORLANDO LOCALITY.

Mr. Frank Furman, a blacksmith of Orlando, Oklahoma, while searching for "mineral" discovered a fossil bed about two miles northeast of Orlando. This fact having come to the notice of Prof. G. W. Stevens, then principal of the Guthrie high school, now of the Northwestern Normal school, he notified Dr. VanVleet, director of the Survey. By the request of Dr. Van Vleet, professor Stevens visited the locality and secured a number of bones. Since that time various members of the Oklahoma Survey have made considerable collections at this place. The "bone bed" from which the greater part of the specimens have been obtained, is located along the bank of a small creek or canyon by the side of the road. It occupies an area of but a few square rods but the amount of material contained thereon is considerable. The fossils are found chiefly in a stratum of soft bluish or greenish clay which form a member of the Red-beds of that region. As the soft clay is eroded by the rain the bones are uncovered. New exposures are made after every heavy rain and the locality may be worked over year after year.

Unfortunately the bones from this place are largely fragmentary, consisting chiefly of single vertebrae, teeth and scales. Nothing like complete skeletons have yet been secured. A number of skull bones have been found, however, and a few nearly perfect skulls imbedded in a lump of clay. The bones are usually quite small. Many of the vertebrae have a diameter the size of that of a lead pencil. Occasionally, however, a vetebra an inch or two in diameter is found.

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(32) Kansas University Quarterly 1900. No. 3, pp. 175-177.
(33) Ibid. Vol. VIII, No. 4.
(34) Geological Magazine, Vol. V, Dec. 1898, p. 295.

The bones collected in this locality were sent to Dr. Williston who under the date of November 24, 1900 wrote me in part as follows:

"The following is a preliminary list of the chief forms that have been discovered.

Diplocaulus magnicornos Cope.
Diadectidae, Gen. indt.
Pariotichus incisivorus (?) Cope.
Labyrinthodont.
Trimerorhachis.

Diplocaulus is an Amphibian. The genus occurs in the Permian of Illinois and Texas, according to Cope. The Diadectidae is a family of Theromorph or Theridont reptiles, known only from the Permian of Texas. Pariotichus incisivorous Cope from the Permian of Texas belongs to a family closely allied to the Diadectidae. Trimerorhachis is a genus of Stegocephs from the Permian of Texas.

Altogether you see that these fossils point unmistakably to the Permian. In all probability there will be new forms among them."

Dr. Williston and Mr. C. C. Case have been working on this material for some time, and Mr. Case's report is included in the present volume.

Several other finds have been reported from the region about Orlando. In digging a cistern a mile east of town a farmer discovered some vertebrae two inches or more in diameter. At Mulhall 6 miles south fragments of leg bones and a vertebra were secured and from the vicinity of Marshall, 12 miles west, some vertebrae and a rib bone a foot and a half long. Bones are also reported from localities east and northeast of Orlando.

This all goes to show that fossils are not particularly rare in this region. It may be confidently expected that remains of animal life will continue to be found in wells, cisterns, and other excavations in future years. It is to be hoped that as these specimens come to light, they may be preserved, and not allowed to lie around and be destroyed as is too often the case.

THE GYPSUM HILLS LOCALITIES.

In the Blaine formation of west central Oklahoma there are two ledges of more or less sandy dolomite, that underlie the two massive gypsum ledges that form the cap of the Gypsum hills. The lower of these ledges is known as the Magpie dolomite and the upper one as the Altona. The Magpie underlies the Medicine Lodge gypsum and the Altona the Shimer. It is this rock, which being harder than any other in the region ressists erosion, that covers the slopes and gives the name Stony hills to this part of the Gypsum hills range. These dolomite ledges are practically continuous for more than 40 miles.

Both the Magpie and the Altona are fossiliferous. In places the rock is literally honeycombed with casts of small shells. In other localities the fossils are wanting, or at least quite rare. Although the number of specimens is so great, there have been but two species determined. According to Dr. J. W. Beede, to whom the specimens were sent for identification, the most abundant of these is Pleurophorus subcuneatuas Meek. Concerning the other species Dr. Beede wrote on November 24, 1902:

"The other specimen is a Schizodus closely related to S. Wheeleri and probably also to S. Meekanus Girty. It is probably a new species peculiar to the upper Permian. However, this can not be determined with certainty until better material can be studied, as the outline of this specimen is incomplete."

THE WHITEHORSE LOCALITY.

The only locality from which fossils have been found in the upper part of the Oklahoma Red-beds is in the vicinity of Whitehorse spring, 16 miles west of Alva, Oklahoma. The horizon is the lower part of the Red Bluff sandstone, the middle member of the Woodward. On July 5, 1900, a considerable collection of invertebrates was secured at this place. The fossils were found in great abundance on a locality occupying perhaps 40 acres along a rather flat ridge just west of Whitehorse spring. They are contained in a soft, red sandstone, so characteristic of the Red Bluff. The geological location of the bed is about half way between the two heavy gypsum formations of the Red-beds, the Blaine and the Greer.

This material was submitted to Dr. Beede, our best western authority on the Permian. His report on the fossils was published as an advance bulletin of the First Biennial report of the Oklahoma Geological Survey in April, 1902. In this report Dr. Beede describes the following new species:

Bakewellia Gouldii.
Conocardium Oklahomaensis.
Aviculopecten Van Vleeti.
Dialasma Schucherti.

In addition to the new forms mentioned above species were found belonging to the following genera: Naticopsis, Pleurotomaria, Pleurophorus, Schizodus, Aviculopecten, Lima, Sedgwickia. Regarding the age of the beds Dr. Beede says:

"On the whole these fossils show an advance over the fossils of the Permian below. Some of the species still persist, as we should expect from the fact that there is no unconformity between these various formations. On the other hand there is a new species of Dialasma belonging to a group new to the American Permian. * * Taking all this into consideration there can be little doubt that the age of these beds is Permian."

ON SOME VERTEBRATE FOSSILS FROM THE PERMIAN BEDS OF OKLAHOMA.

E. C. Case.

The fossils described below were collected by G. W. Stevens, now of the Northwestern Normal School, at Alva, in a locality discovered by Mr. Frank Furman, about two miles northeast of Orlando, Oklahoma. The collection was later increased by additions made by Professor Chas. N. Gould and Dr. A. H. VanVleet, Territorial Geologist.

The collection is of especial interest as it shows a close relationship, both in its forms and its manner of fossilization, to the deposits of northern Texas. Still more interesting is the discovery of forms having the same characters of neural and haemal spines as are found in forms from the Carboniferous of Linton, Ohio, and the Permian deposits of Ireland and Bohemia. Two or three forms, as Trimerorhachis and Diplocaulus are common to this region and the deposits of Illinois, but the fauna is much more closely related, as is to be expected, with that of the Texas Permian. It is perhaps worthy of note that there is a noticeable difference in the fauna of Illinois and Oklahoma and Texas.

Below is a list and description of the forms determined.

PICES.

Elasmobranchii.

Diacranodus (Pleuracanthus) * ampressus (?) Cope.

Diacranodus is the name applied to this form by Garman in 1885, Bull. Mus. Comp. Zool., Vol. XII, and is the name used by Hay in his Catalogue of the Extinct Vertebrata of N. A., Bull. 179 of the U. S. G. S., it has been known variously as Diplodus, Didymodus and Pleuracanthus; see the Catalogue by Hay cited above.

Dipnoi.

Sagenodus (?) sp.

BATRACHIA.

Diplocaulus magnicornis (?) Cope.
Diplocaulus limbatus (?) Cope.
Diplocaulus salamandroides Cope.
Trimerorhachis sp. Cope.
Trimerorhachis leptorhynchus sp. nov.
Cricotus sp. Cope.
Cricotillus brachydens g.et. sp. nov.
Eryops, megacephalus Cope.
Crossotelos annulatus g.et. sp. nov.

REPTILIA.

Pelycosauria.
    Naosaurus sp. Cope.
    Embolophorus (?) sp. Cope.
Cotylosauria.
    Pariotichus ordinatus Cope.
    Pariotichus sp. Cope.
Indet.
    Pleuristion brachycoelous g. et sp. nov.
    Diacranodus (Pleuracanthus) compressus (?)

This form is represented by numerous teeth of the form common in the Texas region. Some of the teeth are of quite large size showing forms of more than the ordinary dimensions.

Sagenodus (?) sp. Several teeth and the crushed fragments of a skull indicate the precence of a Depnoan belonging probably to this genus and seemingly new as it differs from the forms described from the Permean deposits of Texas and Illinois. I am as yet unable to say with certainty that it is new in science.

Diplocaulus, Cope. This genus is represented by a very large number of fragments which form, indeed, the bulk of the collection. The vertebrae are all smaller than the typical species magnicornis and may belong very largely to the species, limbatus or the species salamandroides from the Permian region of Illionis. It is impossible to identify the forms with certainty because of the fragmentary nature of the remains of the skulls and the isolation of the vertebrae.

Two kinds of vertebrae may be distinguished in the collection. 1. Vertebrae of generally shorter and stouter proportions with a flatter, lower surface to the centrum; this may become so decided that the face becomes entirely flat. On the lower surface of these vertebrae the characteristic sculpture of the genus is notably different from the sculpture of the second class of vertebrae. In both the sculpture of the middle portion is running parallel to the greatest length of the centrum generally in long and finely incised lines; running parallel to the greatest length of the centrum in the stouter vertebrae the lines do not extend to the ends of the centrum but become confused near the ends in a complex of vermiculate appearance. 2. The second class of vertebrae are longer and the bottom of the centrum is rounded, the proportions are more elegant and the lines of sculpture extend to the ends of the centrum. These might well be described as distinct species if it were not for the possibility that they come from different portions of the column.

Trimerorhachis insignis (?) Cope. This genus is represented by numerous fragments of the skull and by a single, characteristic intercentrum. There are many fragments of the articular portion of the lower jaws which correspond in size and general characters to the type species, T. isignis. It is possible that other species are represented but it is impossible to determne them.

Trimerorhachis leptorhynchus sp. nov. A somewhat crushed skull indicates the presence of a new species. The skull is imperfect having lost the anterior end of the muzzle and a portion of the articular region of the left side. The whole skull is much longer and more slender than any species of this genus, its proportions being more those of the cricotus than T. insignis. The teeth are mostly hidden but one or two show that they were small and fine. The orbits are directed more upward than laterally and they were of greater antero-posterior extent than lateral. The articular region of the skull project quite far behind the articular portion so that that there is a very prominent excavation of the posterior portion of the skull. The ends of the mandibles do not project posterior to the quadrate. The mandibles approach each other to contact in the posterior 1-3 of their length. The outer side of the mandible is marked by longitudinal lines of sculpture. The whole skull contracts sharply anterior to the occipital region, about opposite the orbits.

Measurements:

Width of the skull at the quadrate region	.038 m
Width of the skull opposite the orbits	.030 m
Projection of quadrate region beyond the midline of the skull	.013 m
Length of the incomplete skull (about .01 or .02 m missing	.052 m

Cricotus sp. Cope. Represented by a single intercentrum indicating an animal of medium size.

Cricotillus brachydens sp. nov. A fragment of a rostrum indicates the presence of a new genus and species of amphibian. The fragment is up from the middle portion of the maxillaries between which appear in the posterior half the anterior parts of the naslas, and on the lower surface the vomers. The upper surface of the maxillaries is sculptured by low longitudinal ridges, especially upon the upper surface. The maxillary is triangular in section, the upper surface is convex and the inner or vomerine side and the dentigerous surface are flat or slightly concave. The inner and lower surfaces meet in a very sharp ridge. The vomers are very narrow but of considerable vertical extent and lie closely apposed to the vomerine sides of the maxillary, they project as sharp ridges on the lower side of the skull. The teeth are represented by the roots alone, their chief characteristic is the relative breadth of the roots, approaching in this respect the Diadectidae. They are from two to three times as wide as long. The tooth line is somewhat concave inwardly following the curve of the maxillary bone and the teeth are anchylosed to the flat dentigerous surface.

Measurements:

Total length of the fragment (about half the length of the head, probably)	.030 m
Width of the anterior end	.015 m
Width of the posterior end	.021 m

Eryops megacephalus, Cope. This form is represented by a single intercentrum indicating an animal of the largest size. It does not differ appreciably from the same genus and species from the Texas regions.

Crossotelos annulatus gen. et sp. nov. A very interesting series of vertebrae which occur quite commonly in the collection indicate the presence of a form that is especially noteworthy from the resemblance which it bears to forms from other localities. Most notable among its peculiarites is the fact that the upper portion of the neural spine and the extremity of the haemal spine in the caudals, are marked by slender striations such as distinguish the genera Keraterpeton and Urocordylus from the Permian of Ireland and Bohemia and the genera Ptyonius and Oestocephalus from the Carboniferous of Linton, Ohio. The vertebrae show the same character of close articulation of the vertebrae that is evidently present in the genera mentioned. In the dorsals there is not a very distinct zygosphene and zygantrum articulation but there is a strong interlocking of the sides of the neural arch by prolonged interdigitations and this character is carried onto the neural arch so that even to the summit the arches interlock almost by craniate suture. In the caudals the interlocking digitations are absent but there are present well defined zygasphene and zygantrum articulation such as are figured by Frisch as present in Urocordylus and described by Cope in Oestocephalus remex.

In the dorsals the top of the neural spine is rather broad and the markings on the sides are very sharp but neither so deep nor so long on the side of the spine as in the genra with which it is compared. On the sides of the dorsals a strong ridge connects the anterior and posterior zygapophyses; the parapophysis extends from another very prominent ridge just beneath this so that there are two parallel ridges on the sides of the centrum in the mid-dorsal series which disappears toward the caudal end. This is a very prominent character, and forms one of the most pronounced features of the genus. In the caudal series the haemal arches are well developed reaching nearly or quite the length of the neural arches. The markings on the sides of the arches, both upper and lower are evident but much fainter than in the dorsal series and much fainter than in the genra with which this one has been compared. The belly was abundantly covered with abdominal scales in the form of slender rods of bone, resembling in this feature again, the forms mentioned above. Another point in the structure of these vertebrae is the abscence of sculpture and the constant presence in both the dorsal and caudal series of a foramen on the side of the vertebrae; in the dorsal it occurs just posterior to and below the parapophsis and in the caudals just below the posterior to the anterior zygapophysis. In all the vertebrae the ends are deeply cupped and the arches are coossified with the centrum.

Measurements:

Length of one dorsal	.0135 m
Length of a second dorsal	.012 m
Heighth of the neural spine from the bottom of centrum	.0205 m
Length of one caudal	.0095 m
Length of the chevron from the bottom of centrum	.014 m
Length of a second caudal	.0095 m
Heighth of the neural arch above bottom of centrum	.0165 m

Naosaurus sp. Cope. A small but characteristic fragment from the neural spine shows the presence of this remarkable genus. The fragment consists of one of the side branches from the neural spine near the base. It is impossible to determine the species.

Embolophorous (?), Cope. There are several teeth in the collection which belong to the large Pelycosauria. It is impossible to determine the genus of the different teeth and it is possible that they may belong to different genera. The largest tooth fragment is a portion of one of the maxillary canines of one of the larger forms and in section it closely resembles Embolophorous dollovianus. There are fore and aft cutting edges which bear very faint serrations. The length of the incomplete fragment is .04 m. The four remaining teeth are smaller and belong in the posterior maxillary or mandibular series.

Pariotichus ordinatus, Cope. A some what imperfect skull corresponds closely in size and characters with this genus and species. The top of the occipital region is gone as is the right ramus of the mandible, but the anterior portion is well preserved. The premaxillaries are broken slightly downward so that the nares look outward and slightly down but normally they looked almost straight outward from the narrow muzzle. As the top of the skull is gone it is impossible to determine the sculpture but the sides of the maxillaries are marked by numerous small pits. The premaxillaries contained four teeth, the anterior two much the larger; they extend down over the anterior end of the mandible as prominent tusks. There are eleven teeth in the maxillary series of the left side; the enlarged maxillary tooth is the fourth from the first maxillary and the last maxillary tooth is very small. The mandibular series does show an enlarged tooth in the middle of the series.

Measurements:

Length of pmx. and mx. tooth series	.022 m
Length of anpmx. incisor, anterior	.055 m

Pariotichus sp. Cope. Numerous imperfect fragments of limb bones and two or three portions of skull show the presence of other specimens of Pariotichus but though it is probable from their size that they belong to the species cited above it is impossible to place them with certainty.

Pleuristion brachycoelous, gen. et sp. nov.: Several series of small vertebrae of characteristic form indicate the presence of a new form whose position is somewhat doubtful. They are chiefly characterized by the union of the parapophyses ad diapophyses in a broad wing-like transverse process, and by the peculiarly broad and large neural canal. The centra are proportionately very broad and the bottom line is devoid of sculpture and with no trace of a keel. The vertebrae are deeply amphicoelous. The neural spine is low and the zygapophyses are relatively large and with flat faces. In some the neural arch seems to be coossified with the centrum and in others it is separated. The transverse process is broader above and becomes narrower below where it curves forward to touch the anterior edge of the centrum. There is no evidence of the presence of an inter-centrum.

Measurements:
Breadth across transverse processes 009
Height from base of centrum to top of neural spine.. 01

CONCLUSION.

The result of the determination of these fossils has been to s the long mooted question of the age of the Red-beds. As state another place this was for many years a matter of uncertainty. determination of the Nardin fossils, the first to be found in the te ry, did not throw much light on the subject. The vertebrates from locality were Permian it is true, but the invertebrates were thoug be Triassic and the leaves were said to resemble Mesozoic types is but just to say, however, in this connection, that Estheria mi the crustacean supposed to be of Triassic age has a wide geo range.

The Nardin and the Orlando localities are at about the same eral horizon. If the sandstone that contains the fossils at N could be traced south it would pass somewhere near Orlando, pro a little to the west of that town. So if there is any difference in th of the two fossiliferous beds the Orlando beds are the older. The number of species from Orlando leaves no doubt as to the age of horizon.

After the fossils from Nardin and Orlando had been identifi Permian and the age of the rocks of the lower part of the Red- settled, the age of the upper part of the series was still a matt doubt. In fact the Dialasma from the Whitehorse locality was identified as a Triassic form. It was afterward determined to Permian age.

The Red-beds of Oklahoma , then, or at least the members as as the Greer formation are of Permian age. So far as known f have not been found in the Quartermaster, the highest formatio the series. Until this shall have been done the matter of the a this member may not be determined with accuracy. There is, how no reason for supposing that the Quartermaster will be found to in age from the lower members of the series.

COMANCHE CRETACEOUS.

CHARACTER OF ROCKS.

In various localities throughout western Oklahoma there is a liar formation known as shell-rock, because of the fact that it is con ed almost exclusively of fossil shells. These are genuine marine shells chiefly oysters. Almost without exception, they occur on the highest hills and usually in scattered patches covering a few square rods or outcropping along a line at the top of the Red-beds.

The shell rock belongs to a much later geological age than do the Red-beds. Between the deposit of the two groups of rock a long time limit elapsed during which the Red-beds suffered several important changes. First, they were raised above the sea bottom in which the salt, gypsum, dolomite, etc. had been deposited. Second, they were extensively eroded or worn away by the action of water. Just how long this action continued we do not know but certainly for a very long period of time. The hills of the old Red-beds were probably higher and the valleys deeper than those of the same region today. Third, they were again sunk below sea level. The shell rock was then deposited upon the unevenly eroded surface of the Red-beds in the then deep sea bottom. Thus the line between the two formations is one of nonconformity as may be seen in nearly every locality where both are exposed. The shell-rock is always deposited upon the top of the eroded Red-beds or sometimes apparently upon the flank of the old Red-beds hill.

If other data were wanting the presence of these shells would furnish indisputable evidence to the fact that the country was formerly covered by the ocean. This fact is so patent to the most ordinary observer that the line of shell outcrops has been designated as the shore of an ancient sea. This is true only in part. That all the rock was deposited in deep sea water is beyond question. It is very probable, however, that there was once much more of the shell-rock than at the present time, and that the shore line extended many miles east of the present line of outcrops. Just how far east will perhaps never be known, nor can we ever hope to determine accurately the former thickness of the beds. Of this much we may be confident, however; the present deposits are but the last vanishing remnants of a once much larger area of shell-rock beds.

The geological age to which these beds belong is known as the Lower, or Comanche Cretaceous. Lower Cretaceous rocks cover large areas in the United States, particularly in New Jersey, Alabama, and on the Pacific coast. The largest single area, however, is in Texas, where the beds are found in great thickness. In southern and central Kansas, also, the Comanche is sometimes 200 or more feet thick. The Kansas exposures are very like those in Oklahoma in that they rest unconformably on the Red-beds and are overlaid by later rocks known as the Tertiary. It is probable that in Oklahoma there are beds of Comanche of considerable thickness west of the line of present outcrops, that are covered by the Tertiary. If this be true their presence should be revealed by deep wells over the western part of the territory and northern Texas.

LOCATION.

In southern Kansas there are two principal localities in which the Comanche is developed. The first of these is at Belvidere, near the head of the Medicine river, and the second of the bluffs on the heads of Bear, Sand, Kiger and Bluff creeks, northwest of Ashland, Clark county, Kansas. In each of these localities the Comanche attains a thickness of about 200 feet. The two areas which are some 75 miles apart, are connected by a thin ledge of shell-rock which follows around the heads of Mule creek, past Nuscatunga and Coldwater to the Clark county areas. A southern outlier of this ledge is found on the Avilla hill south of Coldwater in the southern part of Comanche county. On this hill there is exposed something like 125 feet of Comanche Cretaceous. The hill is but a few miles from the Kansas-Oklahoma line. South of this line shells are reported from a number of localities along the heads of the canyons in the divide between the Salt Fork and the Cimarron, north and north-east of the Big Salt plain of Woodward county. Shells found in the bed of Anderson creek seven miles west of Whitehorse indicate that the headwaters of that creek drain Comanche areas. This would locate the beds in T. 28, R. 17, between 15 and 20 miles south-east of Avilla hill.

South of the Cimarron the shells have been found on the old Camp Supply and Dodge trail at a point on the high divide six miles north of Supply. Three miles west of Camp Supply there are some outcrops on a high point between Wolf and Beaver creeks. A locality three miles east of Woodward near the dolomite points show a few scattered slabs of the shell-rock, and the same material is reported from Indian creek a few miles south. South-west of Richmond there are several points along the divide between the North and South Canadians, where thin ledges of this rock occur. One of these is on the flank of a Red-bed hill 5 miles south-west of Lenora, Dewey county. Along the road two miles south of Taloga a few small outcrops of this rock are also found.

It is in Custer county, however, that the largest areas are located. In the western half of this county the shell-rock outcrops in dozens of localities along the canyons emptying into Barnitz creek and the Washita river. This is especially true of the country between the two streams. Many deposits are found near Gyp and Osceola. One of the best localities seen is on the farm of Mr. A. C. Boner near the Lone Star postoffice, 8 miles south-west of Arapahoe. This farm is on the S. E. quarter Sec. 34, T. 13, R. 18. Rock of this kind is found on nearly every farm in the vicinity but particularly on those south and west of Mr. Boner's.

Some 20 miles west of Arapahoe and two miles south-west of the mouth of Panther creek there are other good exposures of shell-rock and several large slabs 10 feet long and two thick, composed of shells, standing on edge. The rock is said to extend five or ten miles west of this point. Another locality is said to be 16 miles south-west of Arapahoe on the S. E. quarter of Sec. 13, T. 12, R. 18 between Turkey and Hackberry creeks. The rock is also reported from the central part of Roger Mills county some 12 miles south-west of Cheyenne, and thence to the Panhandle of Texas. The location of these last named deposits was gathered from conversation with cattle men. The writer assumes no responsibility for their correctness.

THE TERTIARY.

Lying unconformably on the Red-beds and shell-rock over a large part of Western Oklahoma is a formation deposited during Tertiary times probably in the Eocene. It is generally spoken of as the Tertiary. With some local exceptions this constitutes the upper, as the Red-beds do the lower, formation of Oklahoma. That is, while the underlying rock consists of Red-beds, the surface rock over a large part of the territory is Tertiary. The Comanche Cretaceous shell-rock occupies but inconspicuous areas and is in nearly every case sandwiched in between the Red-beds below and Tertiary above.

AREA.

In general the Tertiary occupies the uplands of the western half of Oklahoma. It is almost always found on the high divides between all the streams. In Woodward and Day counties it composes the extensive level prairies between the Cimarron and the South Canadian rivers. A good part of eastern Woods county is also occupied by this formation. Over the level area in central Oklahoma described under the Red-beds it occupies the uplands, and in some places extends as far east of the line of the Santa Fe railroad.

In almost every case throughout the territory the north slopes of the various streams are covered by sand hills. These often occupy a strip from two to ten miles wide and not infrequently extend from t divide to the bed of the stream. The usual explanation given for t origin of these hills is that the sand from the stream has been blow up by the south wind. That this is in part true it is not attempted deny, but it is very improbable that the theory of wind-blown sand w account for all the Oklahoma sand hills. The fact that pebbles oft an inch in diameter are found on the top of these hills seems to vitia such an argument.

As will be shown a little further on, a great part of the Tertia strata consists of fine sand. It seems more reasonable to look to th formation for the origin of the sand hills and to consider the wind as modifying force in their construction. It is not doubted that in ma instances the sand from the beds of such streams as the South Canadi and Cimarron is blown out across the bottoms, and even forms hills considerable size, but it is not believed that sand (and much less pe bles) would be carried in this way for ten miles or more.

PHYSICAL PROPERTIES.

The Tertiary consists for the most part of clay, sand and grav These materials are arranged in the formation indiscriminately, th is, without similarity of position in different localities. In places t entire thickness of the formation is clay. Again sand and gravels p dominate, or perhaps the three will be mingled in comparatively eq proportions.

The clay is usually white or pinkish and sometimes forms ste banks or cliffs along the bluffs or around the heads of canyons. certain of these peculiar forms of outcroppings the name "Mortar bed has been applied by the Kansas geologists.

The sand is of all degrees of fineness from that of a good siz pebble down to particles too small to be distinguished by the nak eye. It is composed for the most part of quartz, although other m erals are present. The grains when examined under the microsc are usually rounded, indicating the action of water.

"Tertiary pebbles" is the term usually applied by geologists the smooth, rounded, waterworn pebbles scattered so abundantly o the slopes and points throughout western Oklahoma and Kansas. Th pebbles have been washed out of the Tertiary deposits, and, wh still in place, form the gravel beds of the formation. They are f *quently cemented* together and form a hard conglomeratic r known as Tertiary grit. This rock on exposure forms conspicuous ledges. A good example may be seen near the head of Bent's canyon on the trail from Woodward to the Big Salt plain.

The pebbles are of all sizes from that of sand to that of a quart measure. They are composed of various minerals, of which quartz is the principal. Granite, feldspar and other minerals are also present. The distinction between sand and gravel in the Tertiary is simply one of size; for the larger pebbles constitute the gravel and the smaller ones sand.

This material, clay, sand and gravel is cemented together, often by calcium carbonate. A drop of acid placed upon almost any of the material taken from the depth of a few feet below the surface will cause it to effervesce rapidly. In addition to the material named there is also in the Tertiary a small amount of other substances, of which the most important are silt, black sand, and volcanic ash, but they need not be discussed in this connection.

ORIGIN.

The Tertiary is not only the latest important deposit in point of time but it is also the only fresh water formation in Oklahoma (except perhaps some Pleistocene). The Carboniferous, Permain, and Cretaceous are deep sea, or possibly in part shallow water, deposits and contain large numbers of ocean shells. The fossils of the Tertiary on the contrary, are chiefly bones of land animals, mastodons, rhinocerases, camels &c. There has been considerable difference of opinion among geologists regarding the mode of deposition of the Tertiary. There has never been any doubt as to the place from which it came. The Rocky mountains alone could have supplied the vast amount of material that has been spread out over the western part of the plains, for it must be remembered that the Tertiary extends from the Rio Grande to Dakota.

Previously it was thought that the rocks were deposited at the bottom of an ancient fresh water lake that formerly covered the region. Later investigators, however, incline to the idea of river deposits. It appears probable that, at the time when the Rocky mountains were being washed down much more rapidly than now, the rivers which took their rise in the mountains carried the sediment to the plains and spread it out in the form of alluvial fans. Just such deposits are now being made in certain parts of the earths surface today, for instance on the west coast of Mexico, in which place the conditions seem to be similar to those which obtained in this plains region in Tertiary times. The beds themselves show almost no indications of lake deposits and *many* indications of river deposits.

EXTENT AND THICKNESS.

It is altogether probable that the Tertiary deposits at one time covered the entire western part of Oklahoma. The valleys of the present streams have been carved into this formation. In many places all traces of the Tertiary are gone except here and there a quartz pebble. The summit of the Glass mountains may be cited as an example of this fact. There are a few pebbles still remaining on the flat plateau above the gypsum ledge although all other traces of the Tertiary have long since disappeared. In general the south slopes of the streams are cut down into the Red-beds while on the divide and on the north slope the Tertiary remains.

The thickness of the formation varies with the locality. It is of course greatest on the high divides. Throughout a large part of western Oklahoma it perhaps averages 100 or more feet thick. In a few localities, distant from the streams, it may reach the thickness of as much as 300 feet. On the other hand in a great many places there is but a thin blanket of the deposit over the Red-beds, as may be observed in the red soil thrown out from shallow wells.

The action of water on the Tertiary causes extensive erosion. The clay and silt are necessarily first washed out. The sand and gravel in the meantime remain behind. The finest of the sand gradually finds its way down stream. This is the sand that fills the river channels, not only in the Tertiary regions but also far to the east. It is the sand remaining behind, that has never washed down to the rivers, that is blown up by the wind forming sand hills. These hills are usually found on the north side of the streams but occasionally on the south side as well; as for example near the head of the North Canadian between Woodward and Camp Supply, and on the north bank of Red river north of Granite.

OKLAHOMA GYPSUM,

By CHARLES NEWTON GOULD.

INTRODUCTION.

The field work that forms the basis of this report was chiefly accomplished in the summers of 1900 and 1902. In 1900 the writer was a member of the Oklahoma Geological Survey and conducted investigations in northern and central Oklahoma as far west as Dewey and Custer counties. In 1902 every county in the western part of the territory, except Beaver, was visited. During this year the special object kept in mind was the location of gypsum deposits and the estimation of the amounts of available material. During the season the writer was accompanied by Mr. R. S. Sherwin, and Mr. John T. Hefley, the former a student at the University of Oklahoma and the latter a graduate of that institution.

In the preparation of this report the plan has been rather to discuss the deposits of the territory and point out the possibilities of their development than to enter into a scientific discussion of technical points. It is hoped that investigations now being made by Mr. Sherwin and others in the University of Oklahoma will assist in the solution of some of the intricate problems concerning gypsum, for istance, that of the origin of the substance and its mode of deposition. For the present, however, these problems must be left untouched. Perhaps the most comprehensive, general report on gypsums so far published is that of Professor G. P. Grimsley of Washburn college, which constitutes Volume V, of the University Geological Survey of Kansas. The problems mentioned are discussed at some length in this report.

The writer is under the greatest obligations to Professor Grimsley for the kind permission to use material from this report. He has in several instances availed himself of the opportunity. The subjects of General Theories and Origin of Gypsum, General Requirements of a Plaster Mill, and process of manufacture are taken almost verbatim from Professor Grimsley's report.

For the analysis of plaster and the different deposits of gypsum and other rocks, which add much to the value of the report, the writer is indebted to Professor Edwin DeBar, head of the department of chemistry in the university of Oklahoma, and to Mr. R. S. Sherwin.

VARIETIES AND DISTRIBUTION OF GYPSUM.

Gypsum, calcium sulphate, or sulphate of lime,has the chemical formula $\mathrm{CaSO}+2\mathrm{H}\ \mathrm{O}$. If the water is absent the formula is CaSO. In this case the mineral is called an anhydrite.

VARIETIES OF GYPSUM.

The principal varieties of gypsum are. as follows:

1. Earthy, or dirt gypsum, known to plaster manufacturers as gypsite, usually of a yellow or grayish color, often difficult to distinguish at a casual glance from some varieties of soil, light in weight, formed in various ways, usually from solution of gypsum in water,

2. Rock gypsum, compact and massive, usually white or gray but occasionally bluish, reddish, etc., soft, comprising alabaster and ordinary rock gypsum. The specific gravity is approximately 2.32 and the typical composition is 32 1-2 per cent of lime, 46 1-2 per cent of sulphuric anhydride and 21 per cent of water.

3. Concretionary gypsum, found in rounded masses with a more or less radiate or foliate and concretionary structure.

4. Fibrous gypsum or satin spar, usually found in the form of prisms or fine needles, contained in sheets between beds of clay or shale from which the satin spar seems to have been segregated out.

5. Selenite, or spar gypsum, found in transparent crystals, plates or masses, either segregated from gypsiferous shales or occasionally in great masses making one variety of massive gypsum.

DISTRIBUTION OF GYPSUM.

From the earliest times gypsum has been used by the various civilized nations for the manufacture of cement and plaster. The Egyptians used this product. An analysis of the cement of the great pyramid of Cheophs shows that the material used does not vary materially from the ordinary cement plaster, the product of an Oklahom mill, probably not more than the products of these mills would differ among themselves. Transparent gypsum, selenite or alabaster was used by the Greeks and Romans for windows. The boomer among the gypsum hills of Oklahoma has used the same material for the same purpose. The alabaster of the ancients was simply a variety of gypsum and the same material is still used for many kinds of ornamental work.

Gypsum is of very wide distribution both geographically and geologically. It is found on every continent. In Europe it has been mined in Austria, Bohemia, France, Greece, Italy, Norway, Saxony, Russia, and Thuringia. In Egypt it has been used since the time of the Pharos. The ancient Arabians and Persians found it in their country. It is reported from India and China and extensive beds are said to exist in Australia.

In the New World, gypsum is found in both Americas. The largest deposits in the world are said to be in South America. In North America there are numerous regions containing deposits. In both Mexico and Canada gypsum abounds. In the latter country it is found in British Columbia, Manitoba, Quebec, Ontario, Novia Scotia, New Brunswick and to the far northwest along the Mackenzie river.

In the United States gypsum is widely distributed. In the eastern states it is found in New York, Pennsylvania, Virginia, Ohio and Michigan. On the plains it is found in large quantities in Iowa, Kansas, Oklahoma and Texas, while still further west it is known to exist in California, Nevada, Utah, Wyoming and Colorado.

It is found in rocks of practically all geological ages from almost the oldest of the stratified rocks up to the most recent. For instance the Quebec gypsum is found in the Ordovician while that of California comes from the Tertiary. The New York, Ohio and Pennsylvania deposits are Silurian. Some of the Canada gypsums are Devonian. The deposits in Michigan and Novia Scotia are Lower Carboniferous; those in Kansas, Oklahoma and Texas chiefly Permian. The Iowa beds are supposed to be Cretaceous and many of the deposits on the Pacific coast are from Tertiary rocks. It is evident, then, that gypsum is of wide distribution both as to location and the time of deposition.

HISTORICAL RESUME OF OKLAHOMA GYPSUM.

There is very literature on the gypsum of Oklahoma. While the Kansas and Texas deposits have been described at considerable length by various geologists and in various reports, the Oklahoma beds have for the most part escaped notice. In fact until the present time but two articles have appeared in which the gypsum deposits of the territory have been discussed at any length. These are the reports of Marcy in 1854 and Cragin in 1897.

MARCY'S REPORT.

In 1852 an expedition under Captains R. B. Marcy and Geo. B. McClellan passed through what is now the southwestern part of Oklahoma. The object of the trip was to explore the headwaters of the Red river. The party traveled south of the Wichita mountains until the North Fork of Red river was reached, then through the mountains past Tepee mountain, which they named Mt. Webster, and crossed the North Fork just below the magnificent gypsum bluffs in what is now the extreme southeastern part of Roger Mills county, a few miles north of Granite. Captain Marcy's journal contained the following note:

"June 3. We were in motion again at three o'clock this morning, our course leading us directly toward a very prominent range of hills situated upon the north bank of Red river, and immeditely upon the third terrace or bench bordering upon the river valley. Their peculiar formation and very extraordinary regularity, gives them the appearance in the distance, of gigantic fortifications, capped with battlements of white marble. Upon examination they were found to consist of a basis of green or blue clay, with two super-strata of beautiful snow white gypsum, from five to fifteen feet in thickness, resting horizontally upon a sub-stratum of red clay, with the edges wholly exposed, and so perfectly symmetrical that one can with difficulty divest himself of the idea that it must be the work of art, so much does it resemble masonry. In many places there are perfect representations of the re-entrant angles of a bastion front, with the glacis riveted with turf, and sloping gently to the river. Several springs issue from the bluffs, and (as I have always found it to be the case in gypsum formations) the water is very bitter and disagreeable to the taste.

"I am inclined to believe that this same formation extends in a southwesterly direction from the Canadian river to this place, as I passed through a country upon that stream somewhat similar to this, and in a position to be a continuation of it. (1)

And on the next day he made the following observation:

"In our route we have passed near several hills of similar formation to that of the gypsum bluffs before described. Sulphate of lime is found in large quantities throughout this section, and occurs in various degrees of purity, from the common plaster of Paris to the most beautifully transparent selenite I have ever seen. I observed several specimens from one to two inches thick, that were absolutely colorless and limpid as pure water." (2)

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(1) Explanation of the Red River and Louisiana in the year 1852. Exec. Doc. 33d. Congress, 1st session, p. 24, 1854.

The geological specimens obtained on this expedition were submitted to Edward Hitchcock, president of Amherst College, for examination. In his report to Captain Marcy, president Hitchcock discusses the various gypsums as follows:

"Your own description of this formation in your letter of November, 1852, contains a better account of its extent than I can give.

"I have traced this gypsum belt; you observe, 'from the Canadian river, in a southwest direction, to near the Rio Grande, in New Mexico. It is about fifty miles wide upon the Canadian, and is embraced between the 99th and 100th degrees of west longitude. Upon the North, Middle and South forks of Red river it is found, and upon the latter is about one hundred miles wide, and embraced within the 101st and 103rd degrees of longitude. I also met with the same formation upon the Brazos river, as also upon the Colorado and Pecos rivers, but did not ascertain its width.

'Wherever I have met with this gypsum I have observed all the varieties from common plaster of Paris to pure selenite; and among the latter were pieces three feet by four, two inches in thickness, and as perfectly transparent as any crown glass I have ever seen. It is to be regretted that I could not have brought home some of these beautiful specimens; but my means of transportation were too limited. I regard this gypsum belt as a very striking and prominent feature of the country. From its uniformity and extent I do not think there is a more perfect and beautiful formation of the kind known. I have myself traced it about three hundred and fifty miles and it probably extends much further.'

"The vast extent of these deposits (doubtless greater, as you say, than is at present known) will make it accessible to a great number of people. Indeed, from the well known use of this substance in agriculture, as well as other arts, a knowledge of its existence must have an important bearing upon the settlement and population of northwestern Texas.

"The only deposits of gypsum known to me that are more extensive than the one discovered by you are in South America. All along the western side of the Cordilleras, especially in Chili, and interstratified with red sandstone and calcareous slate, beds of gypsum occur of enormous thickness, some of them not less than six thousand feet. * * *

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(2) Ibid. p. 25.

The specimens of this gypsum put into my hands correspond with your descriptions. One of them, of snowy whiteness and compact, it seems to me might answer for delicate gypseous alabaster, so extensively wrought in other lands for ornamental purposes. * * If the splendid plates which you describe occur in any considerable quantity it may hereafter be of commercial value, as it certainly will be of mineralogical interest." (3)

And on page 159 of the same report Pres. Hitchcock says:

"But though your discovery of gold will probably excite more attention, I feel that the great gypsum deposit of the west which you have brought to light, will be of far more consequence to the country."

CRAGIN'S REPORT.

The one who has written more fully concerning Oklahoma gypsum than any other is Professor F. W. Cragin. In 1896 he published a paper entitled "The Permian System in Kansas," in which he discusses and classifies the Red-beds and the sub-jacent Permian rocks. In this paper the name Cave Creek gypsums is given to the heavy gypsum ledges and intervening shales that form the escarpment of the gypsum hills of Kansas and Oklahoma.

The Cave creek is divided as follows:

(Shimer gypsum.
Cave Creek (Jenkins clay.
(Medicine Lodge gypsum.

This is practically the same formation that the writer in this report designates as the Blaine. In the paper referred to Professor Cragin, in discussing the relations of the various beds, says:

"These are the gypsum hills. They are a northern extension of those on the Red and Canadian rivers, observed by Marcy in his Red river expedition of 1852 and earlier reconnaissance, and illustrated in the report of that expedition in 1854." (4)

And again,

"The principal stratum of gypsum described and illustrated in their Red River Report by Capt. Marcy and Dr. Shumard as occurring on the

(3) Lac. cit. p. 159-161.

(4) Colorado College Studies Vol. 6, p. 28. 1896.

Canadian and on the forks of Red river, can scarcely be other than the Medicine Lodge gypsum." (5)

In another place in discussing an Oklahoma locality Professor Cragin remarks:

"Reference has been made to a district especially characterized by natural bridges of the Medicine Lodge gypsum in Blaine county, Oklahoma. The district is at the head of Salt creek, a few miles southwest of Okeene and north of Watonga. The bridges are numerous and in some instances are said to be sufficiently large to permit the passage of a load of hay beneath them." (6)

In 1897 Professor Cragin published a second paper entitled "Observations on the Cimarron Series." In discussing the Cave creek formation he says:

"The development of the Cave creek formation between southern Kansas and northern Texas is practically continuous. The data obtained during the April reconnaissance settled clearly the fact that the Shimer gypsum is no mere local bed, but, as the highest member of the Cave Creek formation, is second only to the Medicine Lodge member and nearly coextensive with the latter within the limits of the formation as at present known. Thus the cave formation is for the most part, as on Cave creek, the southern Kansas locality from which it takes its name, 'tripartite' in character. It is magnificently displayed in the great range of bluffs and buttes which I have called the Marcy range, and which constitutes one of the most striking features of the plains topography, stretching almost uninterruptedly from southern Kansas, apparently at least, to the eastern foot-slope of the Llano Estacado, and of which I have elsewhere described the north-eastern portion. From Okeene, Oklahoma, this range of bluffs may be seen leaving the Cimarron river in the vicinity of Glass mountains and slowly retreating toward the North Canadian, which the gypsum reaches near Darlington. In one of its canyon recesses, nestles the head of Salt creek. East of Watonga and north of the principal heads of Kingfisher creek, the escarpment gives place to an acclivity of such a grade as to allow a somewhat ready passage for the Kingfisher-Watonga Stage-road. With unimportant interruptions due to erosions and blanketing, the outcrop of this great gypsum group extends thence across the Wichita Indian reservation, Washita county, and the southeastern part of Roger Mills county, and is thence continued across either the northern and western parts of Greer county, Oklahoma and Collingsworth and Hall counties, Texas, or across gypsum creek of Greer, and Groesbeck creek of Hardema county (near Quanah); till, reaching the foot-slope of the Llano Estacado, it pursues for an unknown distance, a course roughly parallel with the eastern escarpment of the latter. The lowest member of the formation, the Medicine Lodge Gypsum, whose western and southern limits are unknown, but which is probably the most extensive bed of gypsum in North America, is usually more conspicuous than the Shimer, owing partly to its greater thickness and partly to the fact that the presence of the Shimer gypsum, at a short remove above it, often continues the cliff-front up to the summit of the formation, so that the Medicine Lodge member is seen cut squarely off in the face of the bluff, while the Shimer is more frequently rounded off or reduced by erosion or concealed by detritus from the overlying Dog Creek formation.

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(5) I bid. p. 30.
(6) I bid, p. 37.

At the head of Salt creek in Blaine county, Oklahoma, the Cave Creek has a thickness of 70 or 80 feet, the Medicine Lodge and Shimer gypsum beds being respectively 18 to 24 and 15 to 18 feet thick, and the Jenkins clay nearly equal to the combined thickness of the gypsums. I was surprised to find that the gypsum caves and natural bridges at the head of Salt creek are not developed in any way more strikingly than they are in southern Kansas. Near the upper limit of the brine-spring incline at the head of Salt creek, some of the blocks of gypsum that have rolled down from the Cave creek brow of the canyon have been curiously fluted by the solvent action of rain.

In his Red River report, in a letter quoted by Pres. Edward Hitchcock on page 160, Captain R. B. Marcey described a great 'gypsum belt which he stated that he had traced from 'Canadian river, in a southwest direction, to near the Rio Grande in New Mexico,' mentioning his observation of it from the Brazos, Colorado and Pecos rivers. But on page 99 of the same report he attributes the belt, on the authority of Maj Long, to the Arkansas valley also, confusing it with the gypsums of the Marion (Geuda) formation; and in his 'Map of the Country between the Frontiers of Arkansas and New Mexico,' he makes it cross the Canadian in the eastern portion of the great bends of that river, which would place it in Dewey county, Oklahoma. Nevertheless, I believe that the gypsum-crowned bluffs represented in his 'View of Gypsum Bluffs on the Canadian river,' are not those of Dewey county, which are capped with the much higher gypsum herein described as the One Hors gypsum, but belong to the Cave creek belt and that by some error, the Canadian river segment of this belt was not placed on the map in accordanc with the actual observations of Capt. Marcy, who crossed this portion o the belt in 1849, during his expedition from Fort Smith to Santa Fe It is impossible to say whether all of the southwestern localities of gyp sum which he ascribes to this belt are in the extension of the Cave Creek, as some of his observations may have related to one of the southwestern gypsum horizons; and it seems more probable that he used the term 'gypsum belt' broadly for an elongate tract of country in which gypsum was common, a use which would imply about the same stratigraphic range as is included in the Double Mountain beds of Mr. Cummins. The upper Red River map, however, shows clearly that the gypsum of Gypsum and Groesbeck creeks in adjoining parts of Greer county, Oklahoma, and Hardeman county, Texas, which may be called the Quanah gypsum, from the town of Quanah, near which it is being utilized in plaster mills, was not included in the main part of Marcy's gypsum-belt, since the latter, as represented on this map, is far to the west of Gypsum creek and Mr. Cummins states that the Permian of northern Texas dips to the northwest, a direction in which the surface of the country rises. Whatever doubt may remain as to the relation of outlying parts of the gypsum belt of Marcy's text to the Cave Creek formation, the portion indicated as the 'Great Belt of Gypsum' on his 'Map of the country on the Upper Red River,' and extending from the 'Gypsum Bluffs' and Gypsum Hills,' on the North fork of Red river, belongs to the Cave Creek, and the section of the bluffs on the North Fork given by Dr. G. C. Shumard of Plate 5 of the Geology of the same report, shows that the formation there has its typical tripartite development." (7)

Professor Cragin's error in correlating the Medicine Lodge gypsum with the ledges exposed on the North Fork might very naturally be made by one who never visited the region. The bluffs on the North fork are very similar in appearance to those of the main line of the Gypsum hills, in Blaine county, for instance. As shown in another part of this report, however, the Red river bluffs contain three ledges of massive white gypsum. The uppermost of these is often inconspicuous and was evidently overlooked by Capt. Marcy. It is also pointed out that the Blaine formation containing the Medicine Lodge and Shimer gypsums, dissappears in Canadian county, Oklahoma, and that the ledges exposed on North fork are at a much higher level geologically, and that they belong to the same general horizon as the ledges on the Canadian river in Dewey county as Capt. Marcy suspected.

Besides the reports referred to above there have been but few articles written that have dealt specifically with the Oklahoma gypsums. The writer published a short paper in the American Geologist in 1901, treating, briefly, some phases of the subject. A few general references to the gypsum beds have been made by Marcou, Cope, Adams and others, but none of them were intended as general descriptions of the Oklahoma gypsum deposits.

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(7) American Geologist, Vol. XIX No. 5, p. 358-58, May, 1897.

GEOGRAPHY OF OKLAHOMA GYPSUM.

Area of the General Region.

The gypsum area of which the Oklahoma beds form a part is the largest in the United States so far as known.

The deposits extend practically uninterruptedly from southern Nebraska nearly to the Pecos river in west central Texas. By this I do not mean that the line of outcrops is entirely continuous, but that throughout this entire distance the rocks are more or less impregnated with gypsum. For a great part of the distance, however, the outcrops are continuous and one may travel two hundred miles or more and not once be out of sight of heavy gypsum ledges.

Professor Grimsley has shown that in Kansas the gypsum deposits occur chiefly in Permian rocks. The Kansas Permian consists mainly of rocks of two general classes; 1st, an area stretching across the state from north to south just west of the Flint hills, in which the rocks are limestones and clays and shales, mainly blueish and gray in color; and, 2nd, an area in the southern and southwestern part of the state in which the rocks are typical Red-beds. The Red-beds are higher than the limestones and shales that make up the lower part of the Permian. Both the lower and upper divisions of the Permian as outlined above contains gypsum. That contained in the lower members outcrops not far west of the Flint hills from Nebraska to Oklahoma, in Marshal, Washington, Riley, Clay, Dickenson, Saline, Marion, Harvey, Butler, Sedgwick and Sumner counties. The same horizons extend into Oklahoma and contain the Kay county gypsum.

In the Red-beds of Kansas heavy ledges of gypsum are found in Barber and Comanche counties. These are by far the most extensive deposits in the state. These ledges extend into Oklahoma and nearly across the territory, to a point not more than 12 miles from the Indian territory line. West of these ledges in Oklahoma, and at a higher level, geologically, but still in the Red-beds, are other ledges that extend practically to the Texas line south of Greer county, Oklahoma. Across the Red river in Texas are heavy ledges of gypsum. While the relation of these Texas gypsums to the Oklahoma ledges is not definitely known, yet it is believed that in the main the Texas ledges are at a still higher level geologically than the Oklahoma beds. In Texas these beds extend far to the southwest across the region east of the Staked Plains nearly to the Pecos river.

The Red-beds of both Oklahoma and Texas are presumably Permian in age. In other words all the heavy gypsum deposits in the region under discussion are contained in Permian rocks.

The line of outcrops from southern Nebraska to west central Texas is approximately 600 miles long. The width of the gypsum bearing rocks varies from a few miles to more than 100 miles. Oklahoma is in the center of the region. The gypsums extend to about the same distance both north and south of the borders of the territory. As far as known the most extensive deposits in the whole region are in Oklahoma.

CLASSIFICATION OF THE OKLAHOMA GYPSUM REGIONS.

The amount of gypsum in Oklahoma is practically inexhaustible. With perhaps two exceptions, every county west of the main line of the Rock Island railroad contains enough material to supply the United States with cement and plaster for an indefinite length of time and there are also considerable deposits east of this line of road.

The gypsums of the territory belong to the Permian age. For convenience of discussion all the deposits may be roughly grouped under four general regions, as follows:

1. The Kay county region, occupying the central part of Kay county.
2. The main line of Gypsum hills, extending from Canadian county northwest through Kingfisher, Blaine, Woods and Woodward counties to the Kansas line.
3. The second Gypsum hills, extending along a line parallel with the main range and from 50 to 75 miles further southwest, from the Keechi hills in southeastern Caddo county, northwest through Caddo, Washita, Custer and Dewey, into Woodward and Day counties.
4. The Greer county region, occupying the greater part of western Greer county as well as the extreme southeastern corner of Roger Mills county.

It is proposed in the following discussion to indicate somewhat fully the various localities with an approximation of the amounts of available material in each locality. The order of discussion will be that of the localities given above, and under each locality the various counties will be taken up separately.

METHODS USED IN ESTIMATING THE AMOUNT OF GYPSUM.

The following method was employed to estimate the amount of gypsum in a locality or a county. A ledge of gypsum a foot thick and a mile square was used as a basis. The specific gravity of gypsum was estimated at 2.32, and the weight of a cubic foot of water at 62.5 pounds. From this it was estimated that a ledge of gypsum of the thickness given above would weigh 2,021,184 tons. In the calculation of the amounts of gypsum in a region the odd numbers, 21,184[illegible] tons have been discarded and the weight of a ledge a mile square and a foot thick has been considered as 2,000,000 tons.

In estimating the amount of gypsum in any particular region care has been taken to include only available material. Throughout a good part of the region the deposits are often covered to considerable depths by overlying shales and clays, which make up the upper part of a hill. The ledges, however, outcrop again on the other side of the hill, perhaps a mile distant. In other regions the ledges outcrop along the escarpment of a bluff and disappear entirely beneath the higher hill to the west. In still other localities the ledges do not appear on the surface but their presence is attested by numerous sink holes and by ledges encountered in shallow wells. On the other hand in many places the ledges are exposed over considerable areas. Not infrequently a ledge 20 to 50 feet thick will be uncovered for half a mile or more so that the entire thickness might be removed without being compelled to strip any material from above the ledge.

The deep wells west of the region of gypsum outcrops reveal the presence of this rock beneath the surface. It is encountered at various depths increasing as we go west. In a well at Childress Texas, not 20 miles from the southwest corner of Oklahoma, gypsums were found at a depth of more than 1000 feet. There seems to be no doubt that the ledges which outcrop in the various localities in Oklahoma extend westward for considerable distances, passing deeper and deeper beneath the surface the farther west they extend. It is entirely useless even to conjecture upon the ultimate extent of these deposits. Nothing but an extended system of deep borings between the line of outcrops and the mountains will ever solve the problem.

These deep seated ledges have not been taken into account in making up the results. No deposits have been considered in these calculations that are at a greater depth than 100 feet beneath the surface. In general the ledges discussed are less than 50 feet deep and the greater part of them are exposed upon the surface.

In arriving at results the plan has been to estimate the number of square miles occupied by gypsum. Next the approximate combined thickness of the ledges was determined. In both calculations care was constantly taken to make conservative estimates. The number of square miles was multiplied by the thickness in feet and this by 2,000,000. This product is considered the number of tons of gypsum on the area under discussion.

THE KAY COUNTY REGION.

In the central part of Kay county, Oklahoma, in the region between Newkirk and Blackwell, along the various creeks, Duck, Bois d'Arc, Bitter and others that flow south into the Salt Fork, there are a number of local deposits of gypsite or gypsiferous earth. As a usual thing these deposits are not very extensive. However, they are of sufficient importance that one of the four plaster mills in the territory is located here. Its supply of material is obtained along one of the branches of Duck creek. The mill and its products will be discussed in another place.

The region is slightly rolling. The creeks have carved out broad and shallow valleys in the level prairie. The valley of Duck creek is from one to two miles wide and not over 50 feet deep, sloping gently from the upland to the creek bed. The higher land is prairie and a few trees grow along the creek. The rocks in the country are gray and bluish clays and shales with a few ledges of soft, impure limestone. Few rocks of any kind, however, are exposed, the greater part of the country being practically level prairie with few breaks or washes. It is near the creek bank on a gently sloping surface that the gypsum used in the mill is obtained. The deposit covers several acres, and has been worked out in places to the depth of ten feet or more.

The Kay county deposits belong to the Marion formation of the Permian. The Marion formation extends from central Kansas south through Marion, Harvey, Butler, Sedgwick, Cowley and Sumner counties. The rocks are soft shale and clays, gray to blue in color, with a few beds of impure gray limestones. Gypsum deposits are not uncommon. Plaster mills have been located in this formation at several points in Kansas, notably at Burns and Mulvane. Other deposits are known to exist in Butler and Sedgwick counties and in the vicinity of Geuda Springs. In general, however, the deposits are local and quite limited in amount. The experience has been that a mill located on this formation will use up its supply of available material in a few years and will be compelled to move.

Whether or not there are gypsum deposits of any magnitude along the line of this formation further south than Kay county is not known. Occasionally a deposit is reported from this region, but on investigation it has usually proved to be very limited, and for that reason of no particular economic importance. South of Kay county the blue and gray shales of the Marion formation change into typical Red-beds. Now the Red-beds throughout are more or less gypsiferous. But in general the gypsum is so thoroughly disseminated throughout the rock that it can never be utilized. Its presence, however, is demonstrated by the character of the water in these rocks.

Above the level of the Kay county gypsum there is a thickness of about 1000 feet of red rocks. These rocks, which make up the lower part of the Oklahoma Red-beds, consist chiefly of clays, shales and a few beds of soft sandstones. They occupy the level country in eastern and central Oklahoma between the line of the Santa Fe railroad and the main line of the Gypsum hills. There are in this region a few small gypsum deposits. In a number of localities farmers dig gypsum from a bank, burn it and use the product for plaster and mortar. That the rocks of the region are thoroughly permeated with gypsum and other mineral salts is demonstrated by the fact that the water of the part of the region is so strongly impregnated with the various salts as to render it in many instances unfit for drinking.

THE MAIN LINE OF GYPSUM HILLS.

General Description.

The first considerable gypsum deposit encountered in crossing Oklahoma from east to west.is along the main line of the Gypsum hills. These hills extend uninterruptedly from the vicinity of El Reno, Oklahoma, northwest to Medicine Lodge, Kansas and beyond. The hills are hills of erosion. That is, they have been formed by the action of water, wind, frost and the other elements, on the rocks. There is no evidence either of volcanoes or of any great or unusual upheaval anywhere in this region. The hills were at one time elevated above the ocean in which they have been deposited, it is true, but it was at the same time that all the rest of the great plains were elevated. Instead of having been thrown up to their present level, these hills have in fact been worn down from a higher level to the position they now occupy.

The hills are formed by two, or sometimes three, ledges of massive white, rock gypsum ointerstratified between beds of red clay shale. That is, the gypsum ledges are members of the Red-beds formation. There are red clays below, red clays above, and between the heavy gypsums there are ledges of red clay. The clay and shale is usually soft, while the gypsum ledge is relatively harder, and, following the universal law of erosion, known as the survival of the hardest, the gypsum remains intact after the softer clays have all been eroded away.

The various ledges of gypsum with the interbedded clays and two ledges of dolomite that are found below the gypsum ledges aggregate from 60 to 90 feet in thickness.

1. Now it happens that the shales for 200 or more feet immediately beneath this gypsum are very soft. As stated above, the action of water is constantly at work on the shales, resulting in peculiar erosion forms. The protecting gypsum cap tends to preserve the underlying shales from disintegration. The action of water tends to remove these shales wherever they are uncovered. The result is shown in the almost precipitous bluffs under the gypsum ledge. It not infrequently occurs that there is a sheer cliff of 100 feet or more from an overhanging ledge. The disintegration of the shales tend to undermine the gypsum. All along the bluff huge blocks have fallen off and rolled down the slope into the canyons beneath. These gypsum masses frequently weigh many tons. Sometimes where the slope is more than ordinarily steep these boulders strew the sides of the canyon from top to bottom. The color contrast between the white gypsum, green grass and the blood-red shale is very striking.

It must not be imagined, however, that the gypsum cap formed by any one ledge is constant. While it is true that the gypsum is very massive it is also true that it is quite susceptible to the action of water. Crevices, channels, fissures and tunnels travere the ledges in all directions. Some of the largest caves in the region of the plains are in this formation. The fact of the solubility of the gypsum together with the rapid disintegration of the underlying shales will account for the distinctive erosion forms of the Gypsum hills as a whole.

Viewed from the east the hills appear as a wall crowned with a white band. Nor is the sky line continuous. Numerous breaks occur where the gypsum ledge is wanting, having been dissolved by water and carried away. The general appearance is rather that of an uneven row of flat topped buttes or mesas of various sizes, than a single hill with a continuous escarpment. To these buttes the name "Mansard Mounds" have been given by one writer in fancied resemblance to a mansard roof. (4). it not infrequently happens that a few bold points stand out at a distance to the east of the main ridge. These outliers being more conspicuous, have sometimes received distinct names. The Glass mountains, Wild Cat buttes, Mt. Heman, Cedar Hill, and others may be cited. These will be discussed later. Certain parts of the range have also been given particular names, Stony hills in Blaine county east of Watonga, Chatauqua mountains for the same range extending north to the Glass mountains. The name Marcy range has been proposed by one writer for the entire series of hills. It is well however, that these names, while perhaps more romantic, will never supercede the good old cow boy term, "Gyp. hills."

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(4) Robert Hay Bull, U. S. Geol. Sur., No. 57, p. 22.

The line of outcrops of these hills is general from north to south across Oklahoma. The most northern exposure is on the hills north of the Medicine river, near Sun City, Kansas. Here the ledge outcrops along the north side of the river, approaching nearer and nearer the bed of the stream until it passes from sight a few miles below Belvidere, Kansas. Crossing to the south side it outcrops along the various smaller creeks, constantly rising higher and higher on the hills until it reaches its most eastern exposure in Kansas as the famous Gypsum hills overlooking the city of Medicine Lodge. From this point the hills capped with this ledge bear away to the southwest past Canema and Aetna into the south-eastern part of Comanche county. They cross the state line near the point where the Salt Fork enters the territory. West of Alva the ledge outcrops near Whitehorse and reaches the Cimarron in eastern Woodward county. The gypsum forms the cap of the bluffs which enclose the canyon of the Cimarron from the Kansas line to Woods county, a distance of thirty miles. These bluffs vary from 50 feet in height in the northern part of the county, to nearly 150 feet below the Big Salt plain. They are particularly well developed on the south side of the Cimarron river as far as the Glass mountains. This is the region of bat caves and natural bridges. South of the Glass mountains the ledge bears off to the south, gradually leaving the Cimarron, and approaches the North Canadian at Darlington and El Reno.

It is along this line nearly 60 miles in length from the Glass mountains south that the hills rise as a wall west of the broad valley of the Cimarron. Some of the deepest canyons and most picturesque bits of scenery in Oklahoma are found in this region.

After this very general description of the Gypsum hills as a whole it is proposed to take up the matter somewhat more in detail, and discuss the outcrops of the gypsum in the various counties in which they occur. In this discussion I shall begin at the southern end of the line of hills north of El Reno, Canadian county, and follow the range through Kingfisher, Blaine, Woods and Woodward counties to the Kansas line. In this connection I shall give a number of sections and some analyses of the rock.

Canadian county. This county contains the southern extremity of the main line of the Gypsum hills. The outcrops of gypsum occur in the northwestern part of the county. Some four miles north of Darlington and a mile or so west of the line of the Rock Island railroad a few thin ledges of gypsum begin to appear. These ledges do not persist for any great distance but have the appearance of being simply local outcrops. At this point is located the Okarche Plaster Mill. This is the oldest mill in the territory, and has always been a paying investment. At present it is operated by the United State Gypsum company. The material was originally obtained near the mill but the deposits at this place have been exhausted. At present the gypsum dirt is hauled in wagons nearly two miles to the mill.

From the region of the gypsum mill the ledges of gypsum trend northwest. The bluffs soon become higher and an occasional small butte may be seen. The ledges in this locality are usually inconspicuous, however, and seem to be purely local. That is, they appear and disappear with no apparent regularity. The amount of gypsite, or dirt gypsum in this locality seems to be considerable, although much of it has never been prospected. The amount of material in the county is difficult to estimate on account of the conditions of deposit just mentioned but it is probably in excess of 50,000,000 tons.

Kingfisher county. The row of gypsum hills cuts the extreme southwestern part of this county. The corner of the county is perhaps two and one-half miles southwest of the base of the hills. It is in this vicinity that the massive gypsum ledges, that are so conspicuous further north, begin to be prominent. They appear first as thin ledges, a foot or two thick. In places they are covered with overlying deposits and cannot be seen. Along the west line of the county, however, they begin to be more prominent. The following section which shows the position of the rocks in the region was made on the northeast quarter of section 14, T 15, R. 10, W., at a point four miles north and one west of the southwest corner of Kingfisher county. This section while taken a mile over the line in Blaine county, may nevertheless be considered as representative of the rocks in Kingfisher county and so will be discussed in this connection.

Section 2 miles west of Altona, Okla.

No.	Description.	Feet.
7	Massive white gypsum forming the top of a butte	4
6	Gray fossiliferous and sandy dolomite	2
5	Red clay shale	20
4	Massive white to greenish, selenitic gypsum, weathering into blocks, seen for long distances on the slopes below	3
3	Red clay shale with gypsum bands and concretions	16
2	Massive greenish to white gypsum, with many selenite crystals, appearing a dirty brown at a distance	6
1	Red clay shale with gypsum concretions and thin ledges	55
		106

It will be noticed that in this section numbers 2, 4 and 7 are the gypsum numbers. No. 7 is the upper of the three prominent ledges more fully developed further north. It is known as the Shimer gypsum. No. 4 is the Medicine Lodge gypsum and No. 2 the Ferguson gypsum. Hereafter they will be designated.

The amount of gypsum in Kingfisher county is not large. The area is limited and the ledges are still thin. The total amount of material in sight does not probably exceed that in Canadian county.

Blaine county. The Gypsum hills extend through Blaine county from southeast to northwest for a distance of forty miles. It is along this line that their typical character is perhaps best exhibited. Throughout the entire distance in this county they stand like a wall above the level plains to the east, and the red slopes of the hills with the sinuous white line at the top, marking the position of the gypsum ledges, may be seen miles away.

From the point where the hills pass from Kingfisher county into Blaine the ledges continue to thicken to the northwest, until the region of Salt creek in the north central part of the county is reached. At the same time the bluffs become steeper and higher. In other words as the ledges become heavier they are better able to resist erosion and the shales beneath are eroded to a lower level. The following sections were made along the hills at various points in eastern Blaine county and will illustrate this point.

THE WATONGA SECTION.

This section is called the Watonga section for want of a better name although it is ten miles east and two south of Watonga. It is on the southwest quarter of section 32, T. 16, N., R. 10, W.

No.	Description.	Feet.
8	Massive white gypsum, the Shimer, forming cap of hill	4
7	Gray sandy dolomite	2
6	Red clay with conspicuous green bands near the top	41
5	Massive white gypsum, the Medicine Lodge	10
4	Grayish sandy dolomite	1
3	Red clay	13
2	Massive white gypsum, the Ferguson	3
1	Red clay shale with green gypsiferous bands near the top, and thin ledges of gypsiferous sandstone	54
		126

CEDAR HILL SECTION.

Taken on southwest quarter of section 18, T. 16, N., R. 10, W.

No.	Description.	Feet.
7	Massive white gypsum, the Shimer, forming cap of hill	12
6	Fossiliferous, sandy dolomite	2
5	Red clay with selenite bands	18
4	Massive, white gypsum, the Medicine Lodge	55
3	Red clay with seams of selenite	17
2	Massive, pinkish to white gypsum, irregularly stratified, the Ferguson	5
1	Red clay with layers of concretions and green gypsiferous shales	77
		144

HITCHCOCK SECTION.

This section was taken along the Rock Island railroad some four miles south of Hitchcock, Oklahoma.

No.	Description.	Feet.
8	Massive, white gypsum, the Shimer	8
7	Gray dolomitic sandstone	1
6	Red clay	45
5	White, massive gypsum, the Medicine Lodge	12
4	Gray dolomitic sandstone	2
3	Red clay shales with greenish bands	17
2	Massive white gypsum, the Ferguson	3
1	Red clay shales with thin bands of gypsum	90
		177

BITTER CREEK SECTION.

This section was made on the west branch of Bitter Creek 6 miles or more southwest of Ferguson.

No.	Description.	Feet.
8	Massive, white gypsum, the Shimer	13
7	Gray sandstone	2
6	Red gypsiferous clays	32
5	Massive, white gypsum, the Medicine Lodge	14
4	Red clay	27
3	Pinkish, to white massive gypsum, the Ferguson	8
2	Red clay and shale slope	80
		173

THE RUBEY SECTION.

Section taken on the south canyon at the head of Salt creek at the Rubey Stucco-Plaster company's mill.

No.	Description.	Feet.
7	Massive, white gypsum, the Shimer	15
6	Soft gray dolomitic sandstone	1
5	Red gypsiferous clay	27
4	Massive, white gypsum, the Medicine Lodge	17
3	Red gypsiferous clay with green bands of selenite	25
2	Pinkish, mottled gypsum, irregularly stratified, the Ferguson	4
1	Red gypsiferous clay with thin green and white selenite bands and layers	86
		172

Analysis of gypsums from the various ledges at the Rubey Stucco-Plaster company's mill, Ferguson, Blaine county, Oklahoma.

Gypsum from the lower ledge, the Ferguson gypsum.

	Per cent.
Calcium sulphate	80.09
Water	19.82
Insoluble residue	.65
	100.56

Gypsum from the lower part of the middle ledge, the Medicine Lodge Gypsum.

	Per cent.
Calcium sulphate	79.66
Water	20.22
Insoluble residue	.46
	100.34

Gypsum from the middle part of the middle ledge, the Medicine Lodge gypsum. No. 1 is very hard and is left in large boulders when the softer parts are worn away. It is not used for plaster. No. 2 is softer and sometimes fills the place usually occupied by No. 1.

	No. 1. Per cent.	No. 2. Per cent.
Calcium sulphate	94.94	80.82
Water	4.95	20.89
Insoluble residue	.67	.35
	100.56	102.06

"Marble" gypsum, the middle part of the Medicine Lodge.

Calcium sulphate	94.83
Magnesium sulphate	1.93
Water	2.74
	99.50

"Red marble" gypsum from the middle part of the Medicine Lodge.

Calcium sulphate	84.00
Calcium carbonate	3.41
Magnesium carbonate	2.13
Water	5.38
Oxides of iron and aluminum	.78
Insoluble residue	1.69
	97.39

"Marble" gypsum from the middle part of the Medicine Lodge.

	Per cent.
Calcium sulphate	92.73
Magnesium carbonate	3.15
Water	3.15
Insoluble residue	.33
	99.36

Gypsum from the upper part of the Medicine Lodge.

	Per cent.
Calcium sulphate	78.41
Magnesium carbonate	2.03
Oxides of iron and aluminum	1.38
Water	18.23
Insoluble residue	.41
	100.46

Gypsum from the upper part of the Medicine Lodge gypsum. No. 1 is the rock that makes up the greater part of the ledge and is used for plaster. No. 2 is harder material sometimes found in lumps or masses, and is not used for plaster.

	No. 1. Per cent.	No. 2 Per cent.
Calcium sulphate	78.23	89.30
Magnesium carbonate	.98	1.44
Water	20.75	9.33
Silica and insoluble residue	.34	.16
	100.30	100.23

Gypsum from the lower part of the upper ledge, the Shimer.

	Per cent.
Calcium sulphate	78.22
Water	21.22
Insoluble residue	.87
	100.31

Gypsum from the middle part of the Shimer.

	Per cent.
Calcium sulphate	80.16
Water	20.00
Insoluble residue	.86
	101.02

Gypsum from the upper part of the Shimer.

	Per cent.
Calcium sulphate	79.07
Water	21.00
Insoluble residue	.39
	100.46

Analysis of a thin ledge of satin spar above the Shimer gypsum near the Rubey Stucco-Plaster mill, Ferguson, Oklahoma.

	Per cent.
Calcium sulphate	78.87
Water	20.94
Insoluble residue	.18
	99.99

Analysis of green clay from Stuck's canyon, from below the heavy gypsum ledges that make up the Gypsum hills.

	Per cent.
Silica	64.17
Calcium oxide	1.34
Iron oxide	8.10
Aluminum oxide	14.80
Magnesium sulphate	5.57
Magnesium carbonate	.27
Water	6.54
	100.79

The green color is due to iron which was probably not entirely in the form of ferric oxide, but partly in the form of ferreous oxide.

Analysis of so-called copper ore from Henquenet's canyon on Salt creek, Blaine county, Oklahoma.

	Per cent.
Silica and insoluble silicates	67.43
Iron oxide	16.95
Calcium carbonate	1.85
Magnesium carbonate	5.41
Sodium chloride	4.99
Water	3.40
	100.03

The material analyzed was a concretion-like piece of green clay or shale. It is thought by some to be copper ore on account of its color, but it contains no copper, and the color is due to some form of iron, probably a mixture of ferreous and ferric oxides.

"Honey comb" rock from the bottom of Henquenet's canyon.

	Per cent.
Calcium carbonate	82.21
Calcium sulphate	2.98
Magnesium carbonate	1.36
Oxides of iron and aluminum	1.47
Water	6.87
Insoluble residue	4.11
	99.00

Crystalline gypsum concretions from Henquenet's canyon.

Calcium sulphate	75.20
Magnesium carbonate	1.58
Water	17.32
Oxides of iron and aluminum	2.52
Insoluble residue	4.54
	100.89

Analysis of saliferous shales from which issue the salt springs at the head of Salt creek, Blaine county, Oklahoma. The specimens were both taken from near the Sanders salt plant at the head of Henquenet's canyon.

Green saliferous shale.

Silica and insoluble silicates	67.40
Aluminum oxide	2.93
Iron oxide	3.87
Calcium carbonate	7.64
Magnesium carbonate	7.17
Sodium chloride (common salt)	7.15
Water	3.91
	100.07

Red saliferous shale.

	Per cent.
Silica and insoluble silicates	78.90
Aluminum oxide	1.29
Iron oxide	7.52
Magnesium carbonate	2.61
Water	4.61
Sodium chloride (common salt)	5.28
	100.21

Analysis of Dolomite from summit of hill 6 miles northwest of Geary, Oklahoma.

	Per cent.
Calcium carbonate	42.47
Magnesium carbonate	52.86
Water	1.38
Oxides of iron and aluminum	1.35
Silica and insoluble residue	1.82
	99.88

Dolomite from the summit of the Red Hill 8 miles northwest of Geary, Blaine county, Okla.

	Per cent.
Calcium carbonate	52.41
Calcium sulphate	27.36
Water	8.17
Oxides of iron and aluminum	12.16
Silica and insoluble residue	52.78
	100.88

Two samples from the head of Salt creek.

	Per cent.
Calcium sulphate	77.75
Calcium carbonate	.30
Magnesium carbonate	.98
Oxides of iron and aluminum	20.34
Silica and insoluble residue	.18
	99.76

	Per cent.
Calcium sulphate	74.09
Magnesium sulphate	.39
Water	20.01
Oxides of iron and aluminum	.50
Silica and insoluble residue	5.08
	100.07

These sections are intended to show that the ledges thicken to the north and that at the same time the bluffs become steeper and the hills more prominent. Throughout the region the various ledges are exposed, either outcropping along the side of a hill, or as the cap rock of a bluff or butte. In many places, however, the entire thickness of one of the ledges will be concealed beneath a load of debris. Again the same ledge will be entirely uncovered and will be exposed over an area of several acres. The region along Bitter and Salt creeks is one of the most picturesque in Oklahoma. Here the gypsum hills reach their culmination. The various narrow canyons radiating from the head of these creeks have cut their way back into the soft shales beneath the gypsum ledges and in many places the ledge has been undermined, so that the slopes below are strewn with blocks of white gypsum broken out from the ledges. Buttes and mesas, pinnacles and shoulders, overhanging ledges and caves and an endless variety of erosion forms may be seen in this region. The elevation of the highest hills back of the gypsum ledges measured from the bed of the creek is nearly 400 feet.

In the region around the head of Salt Creek and its tributary, Bitter creek, the Medicine Lodge gypsum, the middle of the three ledges, takes on a peculiar form. The lower half of the ledge, usually a thickness of 8 to 10 feet, is much harder than the rest of the ledge, or in fact of any other ledge of gypsum known in the territory. As seen from below, this part of the ledge is pure white and breaks with an even fracture so that it may often be distinguished a mile away. On closer examination it is found to be very hard and fine-grained, usually pure white, but with an occasional bluish or reddish tint. It takes a good polish and has the general appearance of marble. In fact it is known locally as the Salt creek marble and it is sometimes difficult to persuade farmers who happen to own a part of the ledge that the rock is not valuable for building stone or for ornamental purposes. A chemical analysis reveals the fact that the rock is an anhydrite, that it has a very small per cent of water of crystallization. Ordinary gypsum contains from 20 to 21 per cent of water bound up in the crystal. In the rock from this ledge the amount of water is sometimes as low as 2 per cent.

The area covered by the anhydrite is about ten miles long and a mile or more wide. No adequate explanation of this peculiarity of structure has ever been forthcoming. It is probably because of this relatively harder ledge, which resists erosion, that the marked topographic forms mentioned above, have been made possible.

From the region around the head of Salt creek the line of outcrop of the gypsum ledges trends nearly due north to the Woods county line. A short distance north of Salt creek the hills begin to lose their rough outline and the gypsum ledges become inconspicuous. In many places the ledges are entirely covered. Again they may be seen only along the sides of a canyon. The hills are in most places not more than 100 feet above the level plain to the east, and a person may often ride across the hills without even seeing a gypsum ledge.

The total area covered by gypsum deposits in Blaine county is probably about forty square miles. The approximate thickness of all the ledges is not far from 30 feet. Applying the rule of 2,000,000 tons per square mile a foot thick, this would give approximately two and one half billion tons for Blaine county.

Woods county. The line between Blaine and Woods counties cuts *the gypsum* hills in their most inconspicuous portion. North of this line for a distance of 10 miles or more the hills are low and uneventful and the gypsum ledges usually covered. These conditions continue until the region of the Glass mountains is reached.

The Glass mountains are simply eastern outliers of the Gypsum hills. They consist of a number of flat-topped, gypsum-covered buttes, standing out on the plain and separated from the main line of hills by a valley or gap some three miles across. The greatest length of the mountains from northeast to southwest is about five miles and the average width is perhaps two miles. The ledge forming the escarpment of the buttes is usually the Medicine Lodge. The Shimer sometimes appears on the tops of the various buttes but is frequently absent altogether.

The Glass mountains exhibit to a marked degree a very striking phenomenon often met with in the line of the Gypsum hills. All along the range from Canadian county, Oklahoma to the head of the Medicine river, Kansas, are numerous outliers, standing out on the plains at a distance from the main line of hills. Cedar hill in eastern Blaine county, and Henquenet's butte on Salt creek are noticeable examples along the southern part of the range, while further northwest from the Glass mountains there are scores of similar buttes.

On the Glass mountains the slope of the bluffs below the gypsum ledges is much cut up by erosion. The action of the water on the soft clays has produced all sorts of unusual forms. Small buttes and buttrasses, cones and minarets, pinnacles and peaks, shoulders and ridges, domes, towers, chimneys, gulleys, ravines, and all sorts of fantastic shapes have been carved by nature's artistic hand from the blood-red shales along the slope of the bluffs. Scattered everywhere throughout the shales are thousands of transparent selenite crystals. The sun shining upon these crystals reflects myriads of light points. Seen from a distance these crystals give the slopes the appearance of having been covered with glass, hence the popular name, Glass mountains.

The two following sections were taken, the one on the slope of the Glass mountains, the other at the point where the main line of hills approaches nearest the outliers, two and one-half miles southwest of Roscoe postoffice. They are given to represent the structure in this part of the Gypsum hills.

ROSCOE SECTION.

Taken one mile south and one and one-half west of Roscoe, three miles from the south end of the Glass mountains.

No.	Description.	Feet.
8	Gypsum on hills south, probably the Shimer	10
7	Dolomite forming the top of a butte	2
6	Red clay	20
5	Massive white gypsum, the Medicine Lodge	10
4	Soft dolomite sandstone	1
3	Red clay	18
2	Thin ledge of soft selenite gypsum and sandy red clay, probably representing the horizon of the Ferguson	2
1	Red clay with green bands and gypsum concretions from the valley of Cottonwood creek	120

GLASS MOUNTAIN SECTION.

Taken on the northwestern side of the mountain from the base of the hill to the top of the highest butte.

No.	Description.	Feet.
13	Massive, white gypsum to the top of the hill, the Shimer	13
12	Fossiliferous dolomite	1
11	Red clay	15
10	Massive white gypsum forming the top ledge on most of the hills, the Medicine Lodge	18
9	Greenish clay	4
8	Red clay	8
7	Ledge of gypsum concretions and satin spar	1
6	Red clay	3
5	Bluish dolomite rock, hard	8in
4	Red clay	4
3	Rock like No. 5	6in
2	Thin layers of gypsiferous rock and satin spar in seams	4
1	Red clay shale with concretions and green bands from the base of the hill	150

It will be noticed in these sections that but two massive ledges of gypsum appear. These are the Shimer and the Medicine Lodge. The lower ledge as seen in the region of Salt creek and further south east, the Ferguson, seems to have disappeared somewhere in the region of the low hills between Salt creek and the Glass mountains. At least it does not appear either in this region or farther northwest. Whether or not the member of gypsiferous clay and selenite that appears at the same relative position as the Ferguson, i. e. some 20 feet below the Medicine Lodge is the last vanishing remnant of the Ferguson is not known, but the theory seems plausible. This member is No. 2 of both the Glass mountain and the Roscoe sections.

It is just, in this connection, to mention the fact that Mr. R. S. Sherwin who has studied the rocks in this region perhaps more carefully than anyone else, is of the opinion that the lower ledge of the Glass mountains is the Ferguson gypsum, the same member as the lower ledge on Salt creek. He considers that the upper ledge on the Glass mountains is the same as the one designated by the name Medicine Lodge at Salt Creek, and that it is the upper ledge on Salt creek that disappears before the Glass mountain region is reached.

It is at the Glass mountains that the Gypsum hills first approach the Cimarron river. From this point to the Kansas line through Woods and Woodward counties these hills parallel the river on the south side, rarely being more than a mile or two from it. The trend of the hills which from Salt creek to the Glass mountains has been almost north and south, now changes to northwest and southeast, and so continues to the north line of the territory.

From the Glass mountains northwest the Gypsum hills again take on their rough and broken character. Throughout the entire distance almost to the Kansas line along the south side of the Cimarron river a distance of about 60 miles, the general character of the hills does not differ materially. A general description of the entire region at this point may not be out of place.

The Cimarron river in this part of Oklahoma flows southeast. Into this river at irregular intervals flow a number of creeks. These streams are rarely more than 20 miles long and all flow northeast, practically at right angles to the course of the Cimarron. These creeks rise on the high divide back of the Gypsum hills and soon cut their way through the gypsum ledges into the soft shales beneath, forming rather broad canyons in the old plains formed by the gypsum ledges. These canyons are sometimes ten miles long and near the mouth are often three or four miles wide, but become narrower farther up the creek. Between these canyons and parallel with them, that is, running at right angles to the line of the Gypsum hills, are high ridges formed by the uneroded gypsum ledges. These ridges are from 200 to 300 feet above the level of the river. At the points of many of these ridges are outlying buttes, similar in structure to the Glass mountains but smaller and more inconspicuous. Throughout the region the gypsum deposits cover an area averaging ten miles wide paralleling the river. It is estimated that half of the original amount of gypsum in these hills has been eroded in the canyons, and that half remains forming the ridges.

This is the region of caves and sinks. The gypsum ledges are everywhere cut by master joints. The soft character of the rock renders it easily removed by erosion. Water trickling along these joints forms fissures which often enlarge into sinks. In places the surface of the country is literally honeycombed with these natural shafts extending downward from the surface to a depth of 20 to 50 feet. The soft shales beneath the gypsums are in many instances worn away by water, which enters through the sinks, forming large caves. The entrance to these caves is usually along the side of a canyon or it may be through a sink hole out on the level prairie above the level of the gypsum. These caves are frequently 50 feet wide and in places nearly as high. Some are reported to be more than a mile in length. They are often the abode of a great number of bats that remain in the cave during the day and at dusk come out in a steady stream, which continues sometimes for an hour or more.

With this general description of this part of the Gypsum hills we may now take up the matter more in detail. On passing northwestward from the Glass mountains in southern Woods county one soon begins to cross the small creeks spoken of above. Cottonwood, Pappoose, and Cheyenne creeks have cut canyons far back into the hills, and between these canyons are narrow ridges capped with gypsum. At the end of the ridges are outlying buttes. A mile east of Granton, between Pappoose creek and Cheyenne, are two large buttes. They may be called the Granton buttes. A section made on the most prominent of these is as follows.

GRANTON SECTION.

Taken on a prominent gypsum-capped butte 1 mile east of Granton postoffice miles west of the Glass Mountains.

No.	Description.	Feet.
6	Heavy gypsum ledge capping the butte, the Shimer	10
5	Fossiliferous dolomite	1
4	Red clay	14
3	Massive, white gypsum, the Medicine Lodge	16
2	Sandy gypsiferous rock	2
1	Red clay with bands of gypsum concretions, selenite and satin spar	120

Continuing northwest from Barney creek one crosses Greaver, Road, Main and West creeks, all of which flow into the Cimarron from the south in Woods county. Throughout the region the ledges of gypsum continue to cap the hills between the deep canyons. It is noticeable that the two massive gypsum ledges are becoming thicker and at the same time the intervening shale is thinning out. The gypsum is *also becoming* more selenitic. In the region of the Glass mountains and further south the gypsum rocks are white, fine-grained and massive. In this region the rocks are composed of small semi-transparent selenite crystals, often greenish in color. The following sections illustrating these characteristics in the rocks were taken the one at the mouth of Greaver and the other several miles up the creek from the mouth of Main creek.

Section of hill west of the mouth of Greaver creek.

No.	Description.	Feet.
6	Massive gypsum, somewhat selenitic, the Shimer	15
5	Gray dolomite, somewhat honeycombed	2
4	Red clay shale	10
3	Massive, greenish to whitish gypsum, selenitic, the Medicine Lodge	18
2	Red clay with harder ledges	210
1	Slope from Cimarron river	60
		315

Section taken on Main creek half a mile north east of the bat cave.

No.	Description.	Feet.
5	Massive white gypsum, the Shimer	25
4	Red clay	8
3	Massive white gypsum, the Medicine Lodge	20
2	Ledge of honeycombed dolomite, weathering irregularly	12
1	Red clay slope	140
		205

At the bat cave on upper Main creek the Shimer is 30 feet thick and the Medicine Lodge 23, with the intervening shale but 7 feet thick. This is the extreme thickness of these gypsum ledges observed.

In the southwestern part of Woods county the area of gypsum deposits is about 25 miles long and on an average of 10 miles wide, making in all an area of 250 square miles. Estimating that half of the original amount has been removed by eroson, and that the ledges approximate 40 feet thick, this would give 12 billion tons for this part of the county. There is also an area in the northwestern part of the county that contains perhaps 2 billion tons making an approximation of 14 billion tons for Woods county.

Woodward county. The line of gypsum hills continues uninterruptedly along the south side of the Cimarron river from the Woods county line to the Kansas line. In the vicinity of Heman, a station on the Santa Fe railroad, there are a number of outlying buttes, the most prominent of which are Mt. Heman and Mt. Zion. The first creek northwest of this line of road that flows into the Cimarron is Sand creek. It enters just above these buttes. A section of Sand creek 5 miles northeast of Quinlan is here given.

Analysis of gypsums and clays from near Mt. Heman, Woods county, Oklahoma.

Massive white gypsum, the Medicine Lodge.

	Per cent.
Calcium sulphate	79.50
Magnesium carbonate	1.02
Water	20.23
	100.75

Analysis of magnesium limestone from the hill south of Mt. Heman.

	No. 1. Per cent.	No. 2 Per cent.
Calcium carbonate	77.74	74.28
Magnesium carbonate	16.18	2.30
Water	1.25	2.00
Oxides of iron and aluminum	.78	3.75
Insoluble residue	3.25	14.88
	99.20	97.19

Gypsiferous green clay from below the Medicine Lodge.

	Per cent.
Calcium sulphate	58.06
Calcium carbonate	5.35
Magnesium carbonate	3.49
Water	15.38
Oxides of iron and aluminum	3.27
Silica and insoluble residue	13.58
	99.13

Selenite flakes from Mt. Heman.

	Per cent.
Calcium sulphate	76.76
Magnesium carbonate	.84
Water	19.80
Iron and aluminum oxides	1.45
Insoluble residue	.95
	99.80

The insouluble residue and the oxides of iron and aluminum probably came from a little red clay mixed with the selenite.

Section made on Sand creek 5 miles northeast of Quinland.

No.	Description.	Feet.
5	Red clay with local deposits of gypsum	75
4	Massive, white gypsum, the Shimer	22
3	Red clay	7
2	Massive white gypsum, the Medicine Lodge	30
1	Red clay from creek bed	120
		254

Sand, Chimney, Doe, Long, Slicker, Girl and Bear creeks flow into the Cimarron from the south between Mt. Heman and the Big Salt plain. Each of these creeks has its characteristic canyon separated from the other canyons by a high gypsum-capped ridge. The following section was made at the mouth of Doe creek, Woodward county.

Section made on a butte at the mouth of Doe creek, Woodward county.

No.	Description.	Feet.
4	Massive, white gypsum, the Shimer	25
3	Red clay	5
2	Massive, white gypsum, the Medicine Lodge	30
1	Red clay and shale slope from the river	200
		260

Section made at the high bluff at the southeast corner of the Salt plain.

No.	Description.	Feet.
5	Red clay to top of bluff	15
4	Massive white gypsum, the Shimer	15
3	Red clay	10
2	Massive white gypsum, the Medicine Lodge	24
1	Red clay, with bands of selenite and gypsum concretions from the level of the plain	80
		144

It will be noticed that at the Salt plain, but 80 feet of red shale is exposed below the lower gypsum. This is indicative of the fact that the gypsum ledges are approaching nearer and nearer to the level of the river. The salt plain is 8 miles long up and down the bed of the river which is here about 2 miles wide. The plain is as level as a floor, and covered for the greater part of the year with an incrustration of white salt crystals which glitter in the sun and blind the eye like a snow field. Along the south bank of the river the white salt plain comes up to the red clay cliffs capped with gypsum. North of the river there is a strip of bottom land a mile or more wide between the salt plain and the bluffs.

From the Big Salt plain northwest to the Kansas line the distance is about 15 miles. In this region the country is not so broken as that further down the river. The canyons are not so deep nor the ridges so high. The ledges of gypsum approach nearer the river and at the state line just above the Little Salt plain cross beneath the bed of the stream.

On the north side of the Cimarron the gypsum ledges swing around to the southeast and again parallel the river. A number of creeks flowing southwest enter the river at right angles. These streams have cut the country into a series of canyons and ridges very like those on south of the river further down stream. As named on the map these creeks occur in the following order, beginning on the northwest. Anderson, Keener, Day, Sand, Indian, Houston, Turkey, Red Horse, White Horse and Wild Cat. The gypsum layers continue to outcrop along the bluffs near the river nearly to the point where the latter flows out of Woodward county into Woods. It might be truthfully said that in its way across Woodward county the Cimarron flows in a canyon cut through the gypsum ledges down into the red shales beneath. This canyon varies from 1 to 5 miles wide and is from a few feet deep on the Kansas line to 200 or more feet deep at the Woods county line.

The ledges continue northeast from the Cimarron river, pass into Woods county and cross the Cimarron-Salt Fork divide, a few miles east of Whitehorse postoffice. These ledges reach the Salt Fork in Woods county about 15 miles northwest of Alva. From this point they pass into Kansas and occupy a good part of western Barber, and a considerable area in southeastern Comanche counties. The ledges finally disappear from view beneath the high Tertiary plains north of the Medicine river, west of Sun City, 25 miles northwest of Medicine Lodge.

The amount of gypsum in sight in Woodward county is the greatest of that in any county along this line of hills. It is estimated that an area of 600 square miles is or has been occupied by the gypsum ledges. Deducting one half for erosion and estimating the combined thickness of the ledges at 40 feet the amount will be found to be 24 billion tons.

THE SECOND GYPSUM HILLS.

General Description.

To the west of the main line of Gypsum hills and at a higher level geologically there is a thickness of several hundred feet of red sandstones, shales and clays, with some included ledges of dolomites and magnesian limestones. These formations extend from Woodward county to Comanche just back of and paralleling the line of hills just discussed.

Still further west and at a higher level than the sandstone, clay and dolomite members there is a second line of gypsum hills. This line also extends from Comanche county to southern Woodward and at a distance of from 25 to 50 miles west of the main line of Gypsum hills. In general the gypsum in this region differs from that heretofore described in several particulars. For one thing it is not usually found in continuous ledges. That is, the ledges of constant thickness do not extend for any great distance across the county. On the contrary the stratification is very erratic. Sometimes there is a single ledge in a certain locality, while a short distance away there may be several ledges in the same hill. Ledges appear and disappear with no apparent regularity. Gypsum ledges change to sandstone or clays and back to gypsum again all within the distance of a few rods. Sometimes practically all the thickness of the formation is composed of gypsum; while again in near-by localities sandstones and clays are all the rocks seen.

Another point of difference is that the rocks of this region do not form conspicuous hills as do those farther east. As the ledges are not continuous for any great distance, it naturally follows that no prominent escarpments, such as are so characteristic of the main line of hills, will be formed. In general these gypsums appear on the surface in the form of rounded knolls, or mounds on the top of a divide between two streams, or as long gently flowing ridges. Not infrequently, however, these rocks appear as distinct ledges along the side of a local bluff or perhaps more frequently still along the side of one of the rather deep canyons cut by the small streams into the soft rocks that make up the region. The width of the gypsum outcrops of this region from east to west varies from a few miles to as much as thirty miles or more.

It is proposed to take up the discussion of these rocks by counties beginning on the south and continuing to the northwest, much as in the case of the main line of hills.

Comanche county. The known outcrops of gypsum in this county are rather unimportant. All the deposits so far as known occupy an area of a few square miles along the north line of the county a few miles northeast of Frisco. The gypsum is exposed in irregular ledges along the slope or on the top of rounded hills. The amount of material is not large, perhaps not more than 200 million tons in all. The location of the deposits is such however that a number of mills might be profitably located in the vicinity.

Caddo county. In Caddo county there are deposits of gypsum both north and south of the Washita river. In the region of the Keechi hills in the southeast corner of the county, on the line of the Frisco railroad between Chickasha and Lawton there are deposits of considerable magnitude. These deposits extend from the Comanche county line north to the Keechi hills and beyond. East and west they occupy an extent of some twelve or fifteen miles. In all, the outcrops of gypsum in this locality occupies about two townships. The ledges are not continuous but the gypsum appears as rounded knobs on the prairie or as irregular ledges along the sides of the stream. The gypsum consists of a mixture of hard rock and dirt gypsum. In places the dirt gypsum or gypsite, predominates while in other localities all the material is a rather hard rock. Plenty of localities may be found where a mill could be located for which an abundant supply of dirt gypsum could be obtained. The gypsum in this region is usually not pure white but is either pinkish or dark colored. The following section was taken on Little Washita river west of the point where the Frisco railroad crosses this river. It may be considered a fairly typical section.

No.	Description.	Feet.
5	Red clay shale	50
4	Soft rock gypsum, white and pinkish	15
3	Soft red sandstone	10
2	Red clay shale	50
1	Red sandstone along the bed of river	25
		150

The thickness of many of the ledges in this region is more than that shown in this section. Ledges 50 feet thick are present but it is believed that 15 feet will represent a good average of the Keechi hills locality. Estimating the area at two townships and the thickness at 15 feet the result will be approximately 2 billion tons for the locality.

Analysis of gypsum from the vicinity of Cement, Oklahoma, probably a few miles southwest of that town on the Little Washita river.

	Per cent.
Calcium sulphate	74.45
Calcium carbonate	4.25
Magnesium carbonate	.84
Water	18.61
Oxides of iron and aluminum	.61
Silica and insoluble residue	1.02
	99.68

Analysis of a hard rock from the top of the Keechi hills, Caddo county, Oklahoma.

Calcium carbonate	100.18
Oxides of iron and aluminum	.26
Silica and insoluble residue	.32
	100.76

West of the Rock Island railroad on the hills south of the Washita river there are extensive deposits of gypsum in ledges 10 to 20 feet thick. These deposits are first encountered on the hills west of Hog creek, some 8 miles southwest of Anadarko. Along the hills south of the Washita and west of Hog creek, between that creek and Fort Cobb, these ledges form the cap rock of the bluff and may be seen for long distances. The cross-bedded, red sandstone below is from 125 to 150 feet high, and the gypsum ledge at the top will average from 15 to 20 feet thick. The extent of these deposits is not definitely known, but gypsums are reported 10 miles south of this line of bluffs. There is certainly an area larger than that of a township. With an average of 15 feet in thickness this will approximate one billion tons for this locality. In appearance this gypsum is white or pinkish and forms ledges of rather soft rock, sometimes partaking of the nature of gypsite. The gypsum in this locality is at the same general level as that in the vicinity of the Keechi hills, or of that across the Washita river to the north.

The third locality in Caddo county in which gypsum is exposed is along the divide between Cobb creek and the Washita river northwest of Fort Cobb. The gypsums in this region occur as rounded mounds on the top of the divide. They are in fact but the southeastern extension of the Washita county deposits to the northwest, or perhaps it is more correct to say that they form a connecting link between the Washita county beds and those in Caddo county south of the Washita river. The amount of gypsum in this locality increases as we go up the divide. The most southeastern exposure so far as known is in the northwest quarter of section 13, T. 8, N., R. 13, W. It is a rounded mound occupying perhaps a quarter section, and rising to the height of nearly 100 feet above the surrounding plain, or divide upon which it is situated.

The amount of material in this part of Caddo county will perhaps not approximate more than 500 million tons. This will make a total of three and one half billion tons in the county.

Washita county. The culmination of the second line of Gypsum hills occurs in the eastern part of Washita county. Here as elsewhere the stratification of the deposits is very irregular and it is rare that ledges of gypsum can be traced for any considerable distance. But in this region the surface is practically underlaid with gypsum and at the same time the ledges and round mounds of the gypsum rock may be seen outcropping on every hand. In the region between Mountain View and Cloud chief along the Washita river, there are numerous exposures. At a point 5 miles southeast of Cloud chief at a prominent red butte on the south side of the river the following section was taken.

No.	Description.	Feet.
4	Massive, white gypsum	18
3	Sandstone and red clay	28
2	Massive, white gypsum	8
1	Soft, red, gypsiferous sandstone	75
		129

While this may be considered a typical section of the region, it should not be inferred that the thickness of either No. 2 or of No. 4 remain constant for any great distance. Not two miles from the place where this section was taken, No. 4 appears to be more than 50 feet thick, while at another point No. 2 is thicker than No. 4. In places the thickness of the intervening clay, No. 3, is not more than 10 feet.

Between Cloud Chief and Seger along the Washita, heavy ledges of gypsum outcrop almost constantly. In a well near Seger a ledge 115 feet thick is reported, besides several thinner ledges. From Seger north to Weatherford the gypsum outcrops on almost every hill. Near the head of Cobb creek the following section was taken, showing the relation of the gypsum to the rocks beneath.

Analysis of gypsums from the hills west and northwest of Weatherford, Custer county, Oklahoma.

Gypsum from the cave 5 miles northwest of Weatherford. Thickness of the ledge at this place 60 feet.

No.	Description.	Feet.
4	Massive white gypsum	50
3	Red clay shale and sandstone	30
2	White dolomite	2
1	Red sandstone	75
		137

This rock is a mixture of gypsum with sand and carbonate of lime. The insoluble residue is chiefly sand.

No. 2, the white dolomite is apparently the same ledge that extends across Oklahoma from Washita county to the Kansas line. It is one member of the series of rocks that separate the two extensive gypsum formations. It outcrops in Woodward, Blaine and Caddo counties, always above the level of the eastern or main Gypsum hills and below the level of the hills now under discussion. The massive gypsum, No. 4, represents a typical thickness of the ledges in this region.

The gypsum outcrops along the Washita river as far as the Custer county line and beyond. It is limited on the west by a formation of red sandstone and shale that comes in above it.

The area exposed in Washita county is in excess of 325 square miles. Estimating the thickness of the ledges at 30 feet, a very conservative estimate, the result will be approximately 20 billion tons.

Custer county. Gypsum deposits are found in practically all parts of Custer county. The only places in the county where the gypsums are not found are in the extreme northeastern and the extreme southwestern parts. In the vicinity of Weatherford near the southeastern part of the county ledges more than 60 feet thick have been measured. In the same general region there are often several ledges ten or more feet thick on a single hill. Along the Washita river south of Arapahoe the ledges are prominent and they are found up that river outcropping both north and south of that stream as far as the Roger Mills county line. All the creeks that flow south through Custer county exhibit the gypsum ledges along their banks. Gypsum is particularly well exposed along the various branches of Barnitz creek as far up the stream as the vicinity of Osceola. Near the headwaters of Deer creek in the region around Independence ledges are seen. To the north and west these ledges thin out and in the northern part of the county are rarely more than 5 feet thick. The amount of gypsum in Custer county is difficult to estimate on account of the erratic stratification. A conservative estimate would place the amount at 6 billion tons.

Analysis of gypsums from the hills west and northwest of Weatherford, Custer county, Oklahoma.

Gypsum from the cave 5 miles northwest of Weatherford. Thickness of the ledge at this place 60 feet.

	Per cent.
Calcium sulphate	75.57
Calcium carbonate	1.11
Magnesium carbonate	.40
Water	20.22
Oxides of iron and aluminum	.45
Silica and insoluble residue	1.66
	99.41

Gypsum from a ledge 4 miles west of Weatherford.

	Per cent.
Calcium sulphate	77.38
Magnesium sulphate	.83
Water	20.78
Oxides of iron and aluminum	.67
Silica and insoluble residue	.41
	100.07

Gypsum west of Weatherford 5 miles, near a ledge of sandstone.

Calcium sulphate	27.25
Calcium carbonate	46.73
Magnesium carbonate	1.42
Oxides of iron and aluminum	8.30
Silica and insoluble residue	1.22
	84.92

This rock is a mixture of gypsum with sand and carbonate of lime. The insoluble residue is chiefly sand.

Dewey county. The principal outcrops of gypsum in Dewey county are along the bluffs of the South Canadian river and the creeks emptying into this river. The ledges exposed belong to the same general horizon as those of Washita and Custer counties. In Dewey county, however, there is usually but one ledge. This is a rather persistent stratum from 2 to 5 feet in thickness, which appears on a number of buttes and bluffs in the western part of the county. This ledge is well exposed on the high bluffs across the South Canadian northwest of Taloga and around Lenora. It is also seen all along the bluff back of the J. V. Flats, as far south as Raymond. In the vicinity of Camargo the ledge appears and continues up the north side of the river into Day county. The gypsum is usually massive and white and should make a good quality of plaster. The amount of material in the county is possibly 1 billion tons.

Day county. There is a small area of gypsum in Day county, the continuation of the ledge westward from Dewey county along the bluffs of the South Canadian and its tributaries. This ledge outcrops on the north side of the river along Turkey creek in the vicinity of Stone and beyond. On the south side of the river it appears near Shirley and extends for a considerable distance up the river. The amount of available material in the county will probably not exceed half a billion tons.

THE GREER COUNTY REGION.

The fourth general region of gypsum deposits in Oklahoma is in Greer county and the extreme southeastern part of Roger Mills county. We have reason to believe that the deposits of this region belong to the same general level or geologic horizon as those just discussed under the name of the Second Gypsum hills. In fact in a geologic classification the rocks of these two regions would be described together. However there is a considerable area in southwestern Washita county, between Cloud Chief and the North Fork of Red river where the gypsums are scarcely exposed at all. This area separates the Greer and Roger Mills county deposits from the main region and so differentiates the former region.

In the Greer county region, both in Roger Mills county along the North Fork and in the north part of Greer county, the gypsum ledges are well defined and persist for long distances. In this regard they are like the ledges of the main line of Gypsum hills in Blaine, Woods or Woodward counties, rather than the second line of hills in Caddo, Washita, Custer and Dewey counties. In the greater part of the region there are 5 well defined ledges. These deposits will be discussed under the two counties in which they are located.

Roger Mills county. The deposits in this county are confined to a narrow limit, but in the area of exposures are to be found the finest examples of gypsum bluffs in Oklahoma. Along the north bank of the North Fork of the Red river, extending for a distance of 10 miles or more from the extreme southeastern corner of Roger Mills county up stream is a bluff from 150 to 200 feet high, composed of red clay shal interstratified with ledges of massive, white gypsum. Throughout th greater part of this distance the bluff is precipitous, although ga in the wall appear here and there. There are four ledges of gypsu along the face of this bluff approximating 70 feet in thickness. Thi bluff can be seen from a long distance up and down the river and eve from Headquarters mountain at Granite, 15 miles away.

The following section was taken on North Fork at the upper en of the bluff, three miles south of Carter, Okla.

No.	Description.	Fee
10	Rough weathered sandy dolomite capping the high hill.......	
9	Red and green gypsiferous clay shale	2
8	Massive white gypsum	2
7	Red and green shale	
6	Massive white gypsum	1
5	Red and green clay shale	1
4	Massive white gypsum, occasional thin ledge of sandstone.....	2
3	Reddish and green shale	2
2	Greenish gypsum and gypsiferous shale, becoming hard locally	
1	Red and green gypsiferous clay shale from the base of the hill..	3
		17

The amount of available material along this bluff, estimating t deposits to be a mile wide, is more than one billion tons.

Greer county. The ledges which outcrop on the North fork i Roger Mills county cross under the bed of the river and appear Haystack mountain in Greer county some twenty miles northwest Granite. Haystack mountain is but an outlying butte of erosion carve by the action of the water from the end of the ridge that extends b tween Haystack creek and Elm Fork. The same ledges that appear o the North Fork bluff and on Haystack mountain also outcrop along a the streams tributary to Elm fork in this region. The most promine of these streams are Haystack, Cedar, Hackberry, Fish and Bull creek All these creeks have cut deep canyons through the gypsum ledg down into the underlying shales. The various ledges appear on the c of the bluff on both sides of Elm fork far into Collingsworth count Texas, and on the south side of this stream almost to the city of Ma gum. The following section was taken at the mouth of Hackber creek and will represent the stratification along Elm Fork.

No.	Description.	Feet.
12	Hard cap rock, dolomite	3
11	Red clay	20
10	Massive white gypsum	18
9	Red clay	8
8	Massive white gypsum	20
7	Red and blue clay	5
6	Massive white gypsum, with thin ledges of hard rock	18
5	Stratified red and blue clay	12
4	Bluish stratified gypsum, folded	4
3	Red and blue clay stratified	15
2	White and bluish stratified gypsum	4
1	Red and blue clay from the river bed	8

In southern Greer county there are also extensive gypsum deposits. Whether or not the gypsum in this part of the county belongs to the same ledges that outcrop further north is not known. The only place where exposures have been seen in a locality that connects the two general regions, at Mangum on the Salt Fork, would seem to indicate that the gypsum ledges in the southern part of the county belong to a lower level than those along Elm fork. In general the gypsum deposits in southern and southwestern Greer county do not appear in conspicuous ledges. The country is in general level and few canyons have cut into the plain. Some good exposures are found it is true, as on the bluffs south of Mangum, on Horse branch and on Boggy creek. The presence of the rock is usually revealed, however, by the numerous sink holes that are found in the region and by an occasional exposure along a creek bank. Practically all the wells in the region about Duke and El Dorado and in the region east and west of these towns pass through gypsum ledges. The following section was made on the south bank of Salt Fork of Red river, 10 miles south of Mangum at the point of the bluffs between Salt Fork and Horse branch.

No.	Description.	Feet.
12	Hard rock, dolomite, forming the cap of the hill	3
11	Red and blue clay	12
10	Massive white gypsum	8
	Red clay with ledges of gypsum	24
	Massive white gypsum	12
	Red and blue clay	15
	Red and blue soft shaley rock and gypsum	5
	Red and blue shaley clay	22
4	Bluish gypsiferous rock	10

3	Red and blue clay	
2	Massive white gypsum	
1	Red clay slope from Horse branch	1

On Boggy creek 9 miles northeast of El Dorado the following se tion was taken. It is believed to be fairly typical of the southern part Greer county.

No.	Description.	Fe
8	Hard, massive rock, dolomite, forming the cap of bluffs	
7	Red and green shale and clay	
6	Massive gypsum	
5	Red clay	
4	Clay and hard rock	
3	White massive gypsum	
2	Red and blue clay	
1	Hard and massive gypsum exposed in the creek bed	

The area covered with gypsum in the northern part of the coun is estimated at 250 square miles and the approximate thickness of t ledges at 50 feet. This will give 25 billion tons for that part of t region. For the southern part of the county the area is perha 400 square miles with an approximate thickness of 35 feet, maki 28 billion tons. In all the deposits in Greer county by this estima are not less than 53 billion tons. This estimate is believed to be co servative.

APPROXIMATE AMOUNT OF GYPSUM IN VARIOUS COU TIES.

Classified by counties the approximate amounts of gypsum Oklahoma is as follows:

	Tons.
Canadian county	50,000,0
Kingfisher county	50,000,0
Blaine county	2,500,000,0
Woods county	14,000,000,0
Woodward county	24,000,000,0
Comanche county	200,000,0
Caddo county	3,000,000,0
Washita county	20,000,000,0
Custer county	6,000,000,0
Dewey county	1,000,000,0
Day county	500,000,0

Roger Mills county	1,000,000,000
Greer county	53,000,000,000
Total	125,800,000,000

Classified by regions the amounts are:

Main line of Gypsum Hills	40,600,000,000
Second line of Gypsum Hills	31,200,000,000
Greer County Region	54,000,000,000
Total	125,800,000,000

In this estimate the Kay county gypsums are omitted. These deposits are local and widely scattered and no attempt has ever been made to estimate the amount of material in the locality.

It should not be inferred from what has been said that the regions occupied by the gypsums are valuable for nothing else. On the contrary it is true that several of the counties in which the largest deposits of gypsum are found, are also the best agricultural counties in western Oklahoma. For instance both Washita and Custer counties, not to mention others, are noted corn counties. Some of the finest crops of grain and cotton seen in Oklahoma were seen among the gypsum hills. Fruits and vegetables do well. The abundance of springs and the good growth of nutritious grasses make it an ideal cattle country.

In many of the older states farmers import land plaster at a considerable cost. This land plaster is nothing but raw, uncalcined gypsum. In Oklahoma nature has strewn this fertilizer with lavish hand. If the soil should ever become exhausted, the Oklahoma farmer has but to dig down a gypsum hill and scatter the material thus obtained on his field to renew the fertility of the soil.

GEOLOGY OF OKLAHOMA GYPSUM.

Deposition of the Rocks.

With the exception of the granite and limestone in the region of the Wichita mountains and the limestone and shales in the northwestern part of the territory, in the Osage nation and the counties bordering on the Arkansas river, practically all the rocks of Oklahoma belong to the Permian Red-beds. The exception to this general statement is found in the western part of the territory where later rocks the Cretaceous and Tertiary deposits cover considerable areas. The Red-beds grade upward from the Coal Measures rocks in the Indian territory to the east The history of the deposition of these rocks in brief is as follows.

At the close of the Coal Measures it appears that the greater part of the eastern half of the North American Continent was dry land. It had been deposited in former seas and afterward elevated. At this time also there were considerable land areas in the west. From the Gulf of Mexico to the Arctic ocean extended a long and narrow ocean, a veritable Mediterranean sea, occupying what is now the western part of the great plains. This ocean covered the area now occupied by all or parts of the following states: Minnesota, Iowa, Nebraska, Kansas, Oklahoma, Indian Territory, Texas, New Mexico, Colorado, Wyoming, both Dakotas, and Montana, and extending northward through Canada.

The oldest part of the North American continent is to the east. From the region about Hudson Bay and the Appalachian mountains successive land areas have been laid down in regular order. At the close of each time period a new portion of dry land had been added to the former area, continuously making the continent larger. At one time in this process of continent building the western coast was in the Indian Territory. East of this line was dry land, west was an ocean stretching away to the region by the western mountains. As these processes went on and new deposits were laid down in the then ocean, and as elevation occurred, the coast line was pushed steadily westward. Little by little the land area increased in size by this westward progression of the shore until finally the coast line was somewhere in the region that is now eastern Oklahoma.

CONDITIONS OF SEDIMENTATION.

Throughout all this time sedimentation was practically continuous. Deposit after deposit was laid down in the ocean. Rivers from the old land areas to the east carried their loads of debris into the ocean and bed after bed was formed. Waves beat upon the shores and ground up the rocks into fragments that were carried by currents into deeper waters of still bays. Beds of sandstone were laid down near the coast and deposits of mud and ooze that afterwards became clay or shale were made in the deeper bays. All these deposits reached east to their costal line and extended westward for an unknown distance under the ocean. Each succeeding bed, therefore, overlies the preceding ones, but its eastern limit is further west than those below it. Each bed is succeeded by one above it deposited at a later time whose eastern limit is still further west. It is the orderly succession of these beds, taken together with the effects of subsequent erosion, that gives to much of the present surface its peculiar stair step arrangement.

The conditions of sedimentation remained practically the same until all the rocks of the Red-beds had been deposited. It must not be imagined, however, that the process was uniformly regular. Periods of rapid deposits were followed by periods of no deposit at all as the ocean bottom was successively elevated and depressed. Notwithstanding the fact that the elevation processes were slow and irregular, with many pauses and periods of subsidence, still on the whole the land was gradually being built up and elevated, until finally all the ocean was replaced by dry land, the Mediterranean sea ceased to exist and the continent stretched uninterruptedly from the Atlantic to the Pacific.

CHARACTER OF THE RED-BEDS.

The Red-beds of Oklahoma consist of an undetermined thickness, but certainly of more than 2,000 feet, of rocks consisting chiefly of red clays and shales. Interstratified between these soft rocks are occasional beds of sandstone, gypsum, dolomite, and magnesian limestone. The shales and clays being soft are usually eroded by water. The sandstones, dolomites and gypsums being relatively harder, resist erosion longer. For this reason these rocks form the cap of practically all the hills, buttes, bluffs or other elevations in the region.

The general appearance and character of the rocks indicate that they represent shallow water deposits. Limestones, which are typically deep sea deposits are practically absent from these rocks. Sandstones which represent shore-line deposits are scattered here and there throughout the series. The greater part of the rocks, however, perhaps 80 per cent of the entire series, consist of red clay shales. Now clay and shale are considered as representing deposits made in shallow seas. It is probable that in general they are deposited in enclosed bays or in an inland sea.

But there are other evidences that these rocks were in the main deposited in shallow water. Ripple marks, such as are made by waves, or by the wind, are common in many parts of the region. Prints of raindrops have been observed. Sun cracks made on ancient mud flats are occasionally found. All of these phenomena indicate that the deposits were made in part at least in shallow water. Whether or not there were periods of local subsidence at the time of the deposits of the heavy ledges of gypsum is not known. There is little evidence to support such an assumption.

Another marked feature of the Red-beds is the great scarcity of fossils. Numerous collectors have spent much time in searching for the remains of animal or plant life in the Red-beds of Kansas and

Oklahoma. So far as known not a trace of a fossil has ever been found in these rocks in any one of the half dozen Kansas counties in which the Red-beds are exposed. In Oklahoma, fossils have been found, but only at long intervals. In all, four general localities are known in the territory from which fossils have been obtained. Remains of Vertebrates have been found in the vicinity of Orlando, Logan county. Bones, shells and plants have been obtained at Eddy, Kay county. Both of these localities are near the base of the Red-beds. Along the main line of the Gypsum hills in Blaine county, fossils have been found in the dolomite ledges that underlie the heavy gypsums. Near Whitehorse spring in Woods county, a large number of fossils comprising some 15 species was found in heavy sandstone, the Red Bluff, that occurs between the two heavy gypsum horizons of the Red-beds. The practical absence of fossils in these rocks has been used as an argument to support the supposition that the Red-beds were deposited in an inland sea, perhaps something like the Great Salt lake or the Caspian sea of today. The inference is that the waters were too saline to support life, but that an occasional influx of fresh water made it possible for animals to live for a little while at a time. A return to inland sea conditions and consequent saline water would soon kill off these forms.

Another argument bearing upon the same subject is found in the fact that the greater part of the Red-beds are impregnated with mineral salts. Of these the most abundant are gypsum and common salt. But soda, borax, magnesia, and other salts are not uncommon So abundant are these substances that in many, perhaps most, localities in the region of the Red-beds, the water found in wells has dissolved them in large quantities. To all this water the general name "Gyp. water" is applied. As the common expression has it "Gyp. water tastes sleek and greasy and leaves an after-taste in the mouth." It is not infrequently true, however, that the "Gyp. water" so called, contains but little calcium sulphate in solution, but relatively larger amounts of some of the other salts named above.

It is a well known fact that in the present inland seas various mineral salts are now being deposited from evaporation. As shown in another place, in this report, the normal order of precipitation from evaporation is first gypsum and then after evaporation has progressed for some considerable time, salt is thrown down. In the case of the deposits in the Red-beds, however, the order seems to have been reversed. In several parts of Oklahoma there are large deposits of salt. This substance seems to be contained in saliferous shales. From these shale beds the strongly impregnated water issues in the form of brine *springs.* In places 100 c. c. of this brine will evaporate to 43 c. c. of salt. The peculiar thing is that in every instance the salt horizon is below the gypsum horizon. There are 7 salt plains or regions of salt springs in Oklahoma. 6 of these localities are found in canyons cut out of the soft shales and capped with gypsum ledges. 3 of these localities are found below the main line of Gypsum hills in Blaine or Woodward counties, while the other three are in Greer or Roger Mills counties at the base of the Gypsum hills of that region. In all cases the shales both below and above the saliferous beds, are strongly gypsiferous.

THE ORIGIN OF GYPSUM DEPOSITS.

The subject of the origin of gypsum is one of the most perplexing in all geologic science. Most of the theories so far proposed will account for small deposits of gypsum. The vast extent and thickness of the beds, however, point to wide spread conditions of deposition. In Oklahoma for example, there are ledges more than 100 feet thick, and others more than 200 miles long. In South America beds six thousand feet thick are reported. Any theory which satisfactorily solves the problem must take into account these phenomena. To the mind of the writer no such theory has yet been advanced.

Professor Grimsley in his able report on Kansas gypsum sums up the various theories that have so far been advanced as follows:

THEORIES OF ORIGIN.

Deposition From Sea Water.

Gypsum has been deposited by the evaporation of sea water in enclosed lakes or bays which have been cut off from the ocean. Sea water, according to the analyses in the Challenger reports, contains 3 1-2 per cent of mineral matter. When this is analyzed the following salts are found:

Chloride of sodium (common salt)	77.758
Chloride of magnesium	10.878
Sulphate of magnesia	4.737
Sulphate of lime (gypsum)	3.600
Sulphate of potassium	2.465
Carbonate of lime	0.345
Bromide of magnesium	0.217
Total	100.000

When such a body of water is cut off and evaporated, the gypsum is deposited after thirty-seven per cent of water is removed, and the common salt only after the removal of ninety-three per cent. The normal order would be a deposit of gypsum and then a much heavier deposit of salt. But as ninety-three per cent of the water must be evaporated before the salt would be thrown down, the evaporation might go far enough for the deposition of gypsum, but not far enough for salt; or the salt might be deposited, and subsequently removed by solution. Gypsum deposits are more widespread in nature than salt, but usually occur in thinner beds.

This is the most generally accepted theory for the origin of gypsum, and probably applies to most of our larger gypsum deposits.

Deposition by Thermal Springs.

Gypsum is deposited by some thermal springs, as in Iceland, where it is formed by decomposition of volcanic tufa by acids dissolved in the water. The sulphurous acids become oxodized to sulphuric, and then convert the carbonates, especially of lime and magnesia, into sulphates. Through evaporation the sulphate of lime is deposited, forming layers of fibrous and selenitic gypsum.

Deposition Through Volcanic Agencies.

Dawson, following Lyell, explained the origin of the gypsum in Nova Scotia, as follows: First, there was an accumulation of numerous thin layers of limestone, either so rapidly or at so great a depth that organic remains were not included in any but the upper layers. Second, there was an introduction of sulphuric acid, in solution or in vapor, which was a product of volcanic action. Then for a long time the acid waters acted upon the calcareous material without any interruption from mechanical detritus. The limestone and calcareous matter are changed to the sulphate, and gypsum of good quality accumulated in considerable thickness.

Hunt's Chemical Theory of Gypsum Formation.

Hunt's chemical theory of the formation of gypsum is somewhat complex, but he believed it applied to a large part of the gypsum deposits of marine and fresh water origin. In his own words the theory is as follows:

"1. The actions of solutions of bicarbonate of soda upon sea water separates, in the first place, the whole of the lime in the form of carbonate, and then gives rise to a solution of bicarbonate of magnesia, *which, by evaporation*, deposits hydrous magnesian carbonate.

"2. The addition of solutions of bicarbonate of lime to sulphate of soda or sulphate of magnesia gives rise to bicarbonates of these bases, together with sulphate of lime, which latter may be thrown down by alcohol. By the evaporation of a solution containing bicarbonate of magnesia and sulphate of lime, whether with or without sea salt, gypsum and hydrous carbonate of magnesia are successively deposited.

"3. When the hydrous carbonate of magnesia is heated alone, under pressure, it is converted into magnesite; but if carbonate of lime be present, a double salt is formed, which is dolomite.

"4. Solutions of bicarbonate of magnesia decompose chloride of calcium, and, when deprived of their excess of carbonic acid by evaporation, even solutions of gypsum, with separation of carbonate of lime.

"5. Dolomites, magnesites, and magnesian marls have had their origin in sedimites of magnesian carbonate formed by the evaporation of solutions of bicarbonate of magnesia. These solutions have been produced either by the action of bicarbonate of lime upon solutions of sulphate of magnesia, in which case gypsum is a subsidiary product, or by the decomposition of solutions of sulphate or chloride of magnesium by the waters of rivers or springs containing bicarbonate of soda. The subsequent action of heat upon such magnesian sediments, either alone or mingled with carbonate of lime, has changed them into magnesite or dolomite."

Deposition Through Action of Pyrites Upon Carbonate of Lime.

Pyrites or iron sulphides decomposing in clays may change the carbonate of lime into sulphate of lime, and so form gypsum, usually in rather small amounts and scattered through the clay. (8) (8) The University Geological Survey of Kansas, Vol. V, pp. 76-78, 1899.

OKLAHOMA MILLS.

Conditions of Manufacture.

Notwithstanding the fact, as shown elsewhere in this report, that the gypsum deposits of Oklahoma are practically inexhaustible, still the amount manufactured in the territory is relatively small. For this fact several causes may be assigned. Gypsum is at best a bulky product. Cement and plaster, the manufactured products are likewise bulky. The problem of transportation is always an important one. If freight rates are high the profiit on these products is proportionately reduced. In general, in order that a mill be run at a profit, it is necessary that it be located near a line of road. All the better if the mill is either directly on the road or at best on a spur. For instance if the cost for hauling a ton of plaster to the railroad is $1.00 per ton and the capacity of a mill is 100 tons per day, this represents $100.00 per day that must be deducted from the profits. This will sometimes mean that a mill must run at a loss.

Another question scarcely less important than that of transportation is that of fuel. Coal or other fuel is needed not only to cook the gypsum, but also to run the machinery. In one mill that came under the writers notice, it is estimated that the cost of the fuel necessary to produce one ton of plaster is 52 cents. Mills cannot run at a profit if the cost of fuel is excessive. The Texas mills are now using oil to manufacture plaster. It is claimed that by so doing the fuel bill per ton of cement or plaster is reduced from 52 cents to 23 cents.

Until within the last two years there have been but few railroads in western Oklahoma. The regions of the gypsum hills particularly have not usually induced the building of these roads. It is partly due to this fact that a few years ago, when the gypsum deposits in some parts of Kansas were exhausted and the mills compelled to seek another location, that several of them were moved right through Oklahoma, past some of the finest deposits in America, and were located in Texas. Before the railroads were built into western Oklahoma there were but two cement mills in the territory. One was in Kay county, some 10 miles southwest of Newkirk, but much nearer Peckham, from which point the product was shipped. The second mill was at the southern end of the Gypsum hills in north central Canadian county, between Darlington and Okarche. The Rock Island railroad crosses the divide between the Cimarron and the North Canadian just east of these hills. A spur was built from the main line to the point where the mill was located.

There is one point where a railroad has passed through the line of hills. It is along the line of the Atchison, Topeka and Santa Fe road, in eastern Woodward county. In the vicinity of Tucker, between Heman and Quinlan, along the slope south of the Cimarron river, a score of mills could be located, any one of which would find material sufficient to keep it running for 100 years.

During the past two years railroads have been threading their way like spider's webs across western Oklahoma. Many of these roads pass near gypsum deposits. So far as known to the writer there have been but three mills built up to the present time. Others are located and will doubtless be contsructed within a short time. Those already built are located as follows: The Rubey Stucco-Plaster company's mill at the head of Salt creek, four miles west of Ferguson, Oklahoma; *The American* Cement Plaster company's mill at Watonga; and a mill that is being built at Cement in the Keechi hills in Caddo county, on the line of the Frisco road between Chickasha and Lawton.

THE RUBEY MILL.

The Rubey Stucco-Plaster company's mill is located in north central Blaine county four miles west of Ferguson, Okla. The mill is situated in a deep canyon at the head of Salt creek. At this point the gypsum hills are from 200 to 300 feet high above the level plain to the east. Erosion has cut through the heavy ledges of gypsum capping the bluffs and into the soft shales and clays below, and the canyons are still eating their way into the heart of the hills. The canyon in which the mill is located is perhaps 2 miles long and averages a quarter of a mile wide. There are three ledges of gypsum in the hill with an approximate combined thickness of 35 feet. The material composing all three of these ledges is hard, massive, white gypsum. Between the various ledges are strata of red clay shale from 20 to 30 feet thick. A section taken at this place is given on page 93.

The mill is located about half way up the canyon, or about a mile from the point where it widens out to the plain. Bluffs 250 feet high enclose it on either side. The material used in the mill is obtained from the top of one of the bluffs. The company owns several sections of land in the immediate vicinity and it is estimated that the amount of available material is 30,000,000 tons.

The process of manufacture is in brief, as follows. The rock gypsum is quarried from the ledge in blocks. It is loaded into cars and carried for a distance of 500 feet to the mill down a tramway that extends at an angle of 40 degrees from the top of the bluff to the mill below. The cars are transported by gravity, the loaded car coming down as the empty one goes up. The speed is regulated by a brake at the top of the bluff. The broken rock is dumped from the cars and fed by two men into the crusher which breaks the rock into small fragments the size of a chestnut. From the crusher the broken fragments pass to the buhr mill where the gypsum is ground into a fine flour. This pulverized gypsum is elevated into a storage bin and from there passes into the kettles. In this mill there are two kettles each having a capacity of 6 tons. The cooking of the gypsum proceeds about as described in another part of this report except that it is found necessary to raise the temperature to 400 degrees F. It is cooled, mixed with retarder and hair and sacked in 100 pound sacks. The amount of retarder is usually 7 pounds per ton of plaster. This is estimated to delay the setting of the plaster two hours. Four pounds of fiber to the ton is found sufficient.

This mill was erected in 1901 at a cost of $40,000. The capacity is 150 tons every 24 hours. At present 15 men are employed. The fuel used is coal from the Indian Territory. The plaster is marketed in Oklahoma, Indian Territory, Kansas, Missouri, Arkansas, Tennessee and other states. The plaster manufactured is nearly pure white and in this respect differs from most other plasters on the market. It is said to be of a superior quality and in many places is superceding other plasters. The finishing plaster for the new University Hall at the University of Oklahoma is from this mill.

One point that should not be omitted in the description of this mill is that of water supply. This question is often a serious one in the location of a gypsum mill. As stated in another place the water in the vicinity of the gypsum ledges is often so strongly impregnated with various mineral salts as to be unfit for use. In the case of the Rubey company, however, the water is obtained from a spring in the sand hills three miles west of the mill and at an elevation of 300 feet above it. The water is piped from the spring to a reservoir on the bluff above the mill from which it is drawn as needed. The supply is found to be adequate for all purposes, both for steam and domestic use.

Analysis of plasters made by the Rubey Stucco-Plaster company, Ferguson, Oklahoma. Both samples were taken before the retarder was added.

	No. 1.	No. 2.
Calcium sulphate	94.53	96.44
Water	4.12	3.51
Insoluble residue	.57	.61
	99.22	100.61

THE WATONGA MILL.

The American Cement Plaster Co. has recently put a mill into operation at Watonga, Blaine county, Oklahoma. The mill is located three miles from the gypsum deposits. Both the mill and the beds, however, are on the railroad, the latter being reached by a spur from the Rock Island railroad. The material used is rock gypsum obtained from the Blaine formation in the gypsum hills northeast of Watonga. In this instance it was considered more economical to haul the gypsum to the mill than to locate the mill near the beds.

The cost of the mill was $35,000. The capacity is seventy-five tons daily, with two 8 ft. kettles. Twenty-five men are employed. The fuel used is McAlester coal and the product is marketed chiefly in Oklahoma, Texas, Kansas, Missouri and Illinois. The water supply is obtained from shallow wells. This mill is located out on the high divide in the region of sand hills in which good water is abundant.

THE OKARCHE MILL.

An effort was made to secure authentic information from the owners of this mill but without avail. The following points have been gathered at random, but are believed to be fairly accurate.

This mill has been in operation for several years. The material used is gypsite or dirt gypsum. When the mill was first located the material was obtained at a distance of a few hundred feet, but these deposits were soon exhausted and the gypsite is now hauled in wagons nearly two miles. The mill has two kettles. The water supply is obtained from a spring in the sand-hills back of the mill. This mill is now the property of the United States Gypsum Company.

Analysis of material from the Gypsum mill at Okarche, Canadian county, Oklahoma. No. 1 is the gypsite or earth gypsum used for making plaster. No. 2 is the same after burning.

	No. 1. Per cent.	No. 2. Per cent.
Calcium sulphate	61.00	69.41
Water	18.44	5.66
Oxides of iron and aluminum	1.43	2.42
Insoluble residue	17.95	23.38
	98.82	100.87

THE KAY COUNTY MILL.

The Blackwell Cement company operates a mill one mile east and one and one half miles south of Peckham, Kay county, Oklahoma. This mill was erected in the summer of 1899 at a cost of ten thousand dollars. It is a two kettle mill with a capacity of 100 tons daily and employs from twenty five to thirty men. The material used is gypsite, hauled in wagons to the mill. Fuel is obtained from Kansas, and the product is marketed in Oklahoma, Indian Territory, Kansas, Missouri and Arkansas.

The process of manufacture as given by Mr. Guy McNeal, foreman of the mill, is as follows:

"The raw material is hauled to the mill in wagons from which it is dumped directly over a conveyor belt. This belt carries the material to an elevator of sufficient height to allow the dirt discharged to run into the kettles. This elevator also discharges into another conveyor running close to the top of the dirt shed for the purpose of storing surplus dirt received against stormy weather.

When the dirt is discharged into the kettle it begins to boil and behave very similar to boiling water and emits large quantities of steam which is carried to the outside of the building by pipes provided for that purpose. The dirt must be put into the kettle gradually, and usually requires two hours to fill.

After the kettle is filled the material continues to boil vigorously for some time, when it will be seen to become more quiet and emit less steam. It then begins to settle down hard in the kettle and then again boils vigorously and emits large quantities of steam for a time after which it again rises to the top of the kettle and becomes quiet. A thermometer is inserted and when the required temperature is reached the now calcined product is drawn off through a gate in the kettle into the pit. When the kettle is empty the gate is again closed, the dirt started and the kettle again filled.

From the pit the calcined cement is elevated to a revolving screan which separates the lumps which have not been disintegrated in the process, leaving the flower-like cement to be carried to the cooling bin. From this bin the cenemt is again elevated to a hopper over the mixer. In the mixer the proper amounts of hair and retarder are put in, and when thoroughly mixed the cement is drawn off into sacks and sewed up ready for shipment."

POSSIBLE SITES FOR PLASTER MILLS IN OKLAHOMA.

There are so many places in Oklahoma that might serve as possible sites for plaster mills that one must despair of being able to mention any but the most common of them. As stated in another place the deposits in the territory are not only of wide distribution, but also of considerable thickness in numerous localities. So abundant is the gypsum in Oklahoma that locations which in other states would be eagerly seized upon, are here regarded as inferior.

The possibilities of the region along the line of the Santa Fe railroad between Alva and Woodward, south of the Cimarron river, has been discussed. A dozen or more mills might be put into successful operation in this locality alone. Along the line of the Frisco railroad between Okeene and the North Canadian river mills might be built; and also along the same line in the valley of the Washita between Arapahoe and Cordell. In the same general region mills could be located on the Orient road that is now building. Along the Choctaw there are a number of available sites west of Weatherford, between that city and the Washita river. On the line of the Frisco between Chickasha and Lawton mills might be put in near Cement and between that town and Frisco. On the same road there are advantageous locations on Boggy creek near El Dorado, Greer county.

These locations are all either upon roads now in operation or upon those now being constructed. A number of other roads have been surveyed through the western part of the territory, practically every one of which passes near valuable gypsum deposits. Some of the most extensive deposits, however, are not on a road nor, so far as known, near a projected line. To cite a few instances from scores that could be given, I may mention the following. A number of mills might be located along Elm fork of Red river in western Greer county. At the bluffs along the north fork in the extreme southeastern part of Roger Mills county there is material for a hundred mills. Along the Washita river in eastern Washita county and on the south side of the Cimarron from the Glass mountains to the Salt plain in Woodward county there are deposits well nigh inexhaustible.

PROCESS OF MANUFACTURE.

The process of manufacture of cement and plaster does not vary materially in the various mills. The chief difference is in the first stages of the process and this in turn is dependent upon the kind of material used. The mills that use gypsite, or earth gypsum, do not require the crushing machinery. The material for these mills is loosened from its bed by plowing or disking and loaded into wagons with an ordinary dirt scraper. It is hauled to the mill and elevated to the kettles, and the subsequent processes of manufacture do not differ from that of rock gypsum.

The following descriptions of Kansas mills taken from professor Grimsley's report will answer equally well for Oklahoma mills. (9)

ARRANGEMENT OF MILLS.

On the ground floor of the mill are placed the crusher and nipper. The crusher has face plates or jaws of chilled iron which have a backward and forward crushing motion, operated by steam or water power.

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(9) Lac. cit. pp. 96-115.

Blocks averaging fifty pounds weight are thrown into the machine and crushed into pieces about the size of a man's hand. These small masses drop from the crusher into the cracker or nipper, which is set in the floor just under the crusher. This machine, with its interior revolving shaft, works somewhat like a coffee-mill, and further crushes the gypsum into fragments of the size of small gravel, which fall into the buckets of a chain elevator, whereby they are raised to a bin on the second floor. From this bin the gypsum particles pass through a spout into either an ordinary buhr mill or a lime disintegrator, where it is ground into flour.

After the gypsum is ground into flour it passes into another chain elevator and is carried to the top of the second story into the storage bin located just over the kettle. Some of the new mills are using a blower and air blast to drive the gypsum to the upper portion of the mill. This is a new method, and there seems to be some opposition to its use on the part of certain operators.

The ground gypsum is run slowly from the storage bin into the calcining kettle, which is kept at a temperature of 212 degrees F., or over, taking about one hour and a half to fill it to a depth of five feet. These kettles are constructed of boiler steel three-eighths of an inch thick, and are usually eight feet in diameter and six to eight feet deep. They are set like a boiler upon a stone or brick base, and surrounded by a wall of stone about two feet thick with an air space between. The kettle bottom is convex upward and made of steel five-eigths inch in thickness. Such a kettle will hold seven and one-half tons of ground rock or earth. The gypsum is constantly stirred on the bottom of the kettle by two revolving arms with disks fastened to them, in order to keep the material from burning on the bottom. These arms are fastened to a four-inch verticle shaft which is driven by a five-foot horizontal crown wheel, set in motion by a one-foot verticle pinion wheel attached to the power shaft. It takes from ten to twenty horse-power to run this stirrer, and sometimes, if plaster is run too rapidly into the kettle, the resistance is sufficient to break the teeth or cogs from the pinion wheel. The stirrer makes about fifteen revolutions per minute.

The kettle has two or four flues passing through. The heat comes up under the kettle and passes through the air space at side and then through the flues out into the air space on the other side and out through the chimney.

In an hour after the kettle is filled the temperature reaches 230 degrees F. and the mass is seen to be boiling vigorously as the water is driven off and out through the vapor stacks above. When the temperature increases to 270 degrees F. the gypsum settles down solid, leaving twelve to sixteen inches of vacant space at the top, and the steam ceases to rise. At 280 or 290 degrees F. the mass boils down again, often throwing part of the material over the edge of the kettle. When a temperature of near 350 degrees F. is reached, the plaster is rapidly withdrawn from through a gate near the kettle bottom controlled by a lever above, into a fire-proof bin on the ground, and the kettle is refilled.

USE OF RETARDERS.

During the process of calcination, about one half hour before the operation is completed, some manufacturers add a retarder in order to hold back the time of setting of the plaster. Plaster made from gypsum rock will set in six to ten minutes, and retarders are added in sufficient amount to hold back the set for two to six hours, or in extreme cases for twenty-four hours, in order that the workmen may have time to spread the plaster on the wall and properly trowel it down. Various substances have been used for this purpose. In the earlier days of cement plaster glue water was added by the workmen as they used the material; but this was troublesome, and often resulted in poor work from neglect to use the right amount or failure to thoroughly mix the parts. The trade demanded a plaster already retarded in a way that would give uniform results.

Citric acid was used for a time, in the proportion of about two pounds to the ton of plaster, but this was expensive, and the results were often uneven. Magnesian limes are known to set much more slowly than the pure calcareous.limes, so it was thought that the addition of such magnesian limestone would retard the plaster of Paris, but this proved a failure. Sours and sweets form the worker's rule for retarders, and sorghum formed a cheap and successful retarder.

At the present day patent retarders are used, known as Challenge, Iola, Webster City, etc., and they are used commonly in the proportion of six to fifteen pounds to the ton. In the old days of the Romans, blood was used to retard the set of plaster of Paris, and today the organic material of tankage from packing-houses is found to bring about the desired results.

These retarders are manufactured from all sorts of substances in various combinations; such as, glue, glycerine, sawdust, slacked lime, sand, sugar, soda, oil, muriatic acid, paper pulp, salt, copperas, flaxseed, molasses, etc., etc.

The exact influence of the retarder upon the plaster is not known, but it seems to hold the water and so hinder the rapid crystallization of the plaster. Whether this weakens the cement plaster or not is a disputed question among architects and plasterers.

It is very doubtful whether a good mineral or organic retarder will injure the plaster. The fact that it hinders the set or crystallization of the plaster would lead to the inference that the plaster would not be injured, for it merely delays the time, and the resulting crystal network would be as strong as though no retarder was there. Poor retarders, by their decay, would probably weaken the plaster, but where used in small amounts the effects should not be very great. The safe method would be, to use good retarders, which are not subject to decay, and to use them in small amounts.

After the hot plaster passes from the kettle to the ground bin it remains about an hour to partially cool and then it is raised to the second story. It is next bolted, or screened in some way. In some mills ordinary flour bolting machines are used, while in others the plaster descends into a horizontal cylindrical reel, forty inches in diameter and ten feet long, slanting downward three-eighths of an inch to the foot. This is made of brass wire cloth about forty by forty meshes to the inch. The tailings, or screenings, usually about one per cent in amount, are carried back to the buhr mill and reground. The fine plaster is run into one hundred pound sacks, or two hundred and fifty pound barrels and is ready for shipment.

GENERAL REQUIREMENTS OF A PLASTER MILL.

In connection with the discussion of the methods of manufacturing the different grades of plaster of Paris and cement plaster, it may be desirable to give a short discussion of the most important requirements for a modern plaster mill.

As has already been stated, the difference in the mode of manufacturing plaster from the rock gypsum and from the gypsum earth consists essentially in but two points: first, in crushing the rock gypsum so as to reduce it to a powder before calcining; and second, in mixing a little more retarder with the plaster before it is made into the mortar. As the trade demands a plaster ready for immediate use, the retarder is now universally mixed with the plaster at the factory. As the methods of crushing the rock gypsum and of grinding the plaster to a fine powder having already been described in considerable detail, nothing further need be added to such descriptions.

The essential requirements for a gypsum plaster mill may be enumerated *as follows:* First, the most convenient location possible considering the character of the grounds around the mine and the proximity of the mine to one or more rail-road lines; second, the proper arrangement of the buildings with reference to each other, having regard for the cost of the buildings, the conveniences afforded by their arrangement, and the safe guards against fire, etc.; and third, the internal arrangement of calciners and machinery.

The exact location of a plaster mill is often a difficult question to decide. When the mines are some distance from a railroad, the raw material must be either hauled to the mills, or the mills must be located at the mines and the finished product hauled to the road.

In some instances a company would certainly be justified in building a switch from the nearest railroad point to the mines. This question is one which should be decided upon the merits of each individual case. If the deposit of gypsum is small, a company would not be justified in going to much expense to build a switch to the mines. Neither would one be justified in building a switch very many miles in length, unless the gypsum deposits were sufficiently large to warrant a strong company in contemplating the manufacture of plaster on a large scale for a long time. Also the character of the ground over which the road must pass is a factor of great importance, and which must be determined for each individual case. Rail road companies are generally willing to construct their own lines whenever the prospective amount of freight is sufficiently great.

Should the mine be too far away from railroads the present prices of gypsum cement plasters will not warrant the establishment of mills, no matter how abundant the material may be.

Other instances may occur where the mines are located near by the railroad line, and yet some distance away, so that a switch must be built or the produce must be teamed. In most cases, if the deposit is sufficiently large, it would seem that the better way would be to build a switch to the mines and locate the mills at, or near by the material to be used. This is particularly true where the surface is even, so that the grading would be light. If the company is sufficiently strong to manufacture plaster at all, it is probable it will furnish enough freight to justify a railroad in placing the ties and steel on a graded road bed.

INTERNAL ARRANGEMENTS OF CALCINERS AND MACHINERY.

The operations to be performed in the gypsum plaster mill are; 1st. Obtaining the raw material; 2nd. calcining the same; 3rd. intimately mixing the plaster with the fiber, as the markets now demand; 4th, packing the finished product in bags or barrels ready for shipment; and 5th, storing the same ready for shipment. With mechanical devices as highly developed along other lines of manufacturing enterprises as they now are, it is desirable that a plaster factory should be constructed so that the handling of the material throughout all stages of the process should be done by machinery. There is no more reason for handling any of it by hand than there is for our common flouring mills to handle the grain by hand—an old process which is entirely unknown to modern milling. The material should be brought from the mines by mechanical appliances to the greatest possible extent. If it is rock gypsum, some handling will be necessary at the mines, as the mining methods require it. But after it is loaded into the car there is no reason under ordinary circumstances, why it should be touched by shovel or hand until it is packed ready for shipment.

If the material is gypsum earth, even the mining operations could be conducted profitably by machinery. With the many dredging devices now used for lifting sand from the bottom of rivers, and the various spring shovels employed in the large brick factories for lifting the clay from the pit, and other similar devices, it would seem that the old fashioned way of handling the gypsum earth by hand, or with team and scrappers, should be replaced by mechanical devices. After the material reaches the mill, no matter in what form it comes, it can readily be passed through the crushers, filled into calcining kettles, elevated from the hot-pits to the bolts, cooled by the process of elevation, carried from the bolts to the mixers, and from the mixers to the devices for packing, entirely by mechanical operations. So long as steam power remains cheaper than man power such mechanical devices will be desirable.

USE OF GYPSUM.

The two chief uses to which gypsum is put are for land plaster and cement plaster. Raw gypsum, that is, the material in its uncalcined state, is used in many countries as a fertilizer.

When so used it is known as land plaster. It has been thus used for hundreds of years in Europe, particularly in Germany. Among the *older states gypsum is* used for land plaster in New York, Michigan, Maryland, Ohio and Virginia. In general, the fertilizer has been found to be most beneficial for cereals and leguminous plants. So far as known, gypsum has not been used to any extent for a fertilizer in Oklahoma. Some inquiries have been made for such a product, but, at present, the writer knows of no place where it is being used. It should be a matter of extreme satisfaction that the amount of this fertilizer is practically inexhaustible. Land plaster is also used as a disinfectant about houses and stables. It absorbs the ammonia and offensive acids. Its use in this regard seems to be increasing.

The greater part of the gypsum mined in the United States is made into cement plaster. So far as known, all the gypsum manufactured in Oklahoma is so used. A cement plaster is a plaster that sets in from two to twenty hours. It differs from plaster of Paris chiefly as to the time required for setting, the latter requiring but a few minutes. By the use of retarders, the set may be delayed for several hours.

"The gypsum cement plasters are displacing the old lime plasters in all the larger buildings and in many private residences. The advantages of such plasters are as follows: Being a good non-conductor of heat, the cement plaster is valuable in fire proof buildings. It sets more quickly and dries out much more rapidly than lime plaster, so that carpenters can follow the plasters very soon after the plaster is placed on the walls, as can also the painters and paper hangers. Coloring matter can be mixed with the material in its preparation for mortar to produce any tint desired, as the gypsum plaster does not affect coloring matter as lime plaster does. The cement plaster requires less mortar than other plasters, and ceilings and walls thoroughly soaked from leaking and unprotected roofs have not been injured. It attains a high polish and is used for wainscoting as a substitute for marble. Changes of temperature do not affect the walls, and therefore they do not chip or crack. The walls become dense and hard, and are vermin proof, so that the plaster is valuable for hospital walls.

"The great objection to the use of cement plaster has been the greater expense. It costs about one-fourth more than ordinary lime plasters, but the results are so much better that it is bound to displace them more and more as its advantages become recognized."

Besides the two uses named above, which are by far the most important, gypsum has been used for the following purposes: For fire-proof buildings, for molds, as an absorbant, as an adulterant for foods, as casts for broken limbs, for crayon and for certain cheap paints.

PLANTS OF OKLAHOMA.

A. H. Van Vleet.—Introduction.

The following list includes the plants of Oklahoma that are now in the herbarium of the survey. Although the list is a large one, and includes a great number of species never before reported for the territory, it was thought best not to attempt a catalogue at this time, as the range of many of the plants is not yet determined. A catalogue is in preparation, and it is hoped that it will be completed for the next report.

The nomenclature and the arrangement of the families is the same as that found in the "Flora of the Northern States and Canada," by Britton and Brown. The genera under each family are arranged alphabetically.

LIST.

PTERIDOPHYTA.

POLYPODIACEAE.

Adiantum Capillus-Veneris L.
Asplenium ebeneum Ait.
Asplenium platyneuron (L.) Oakes.
Asplenium Trichomanes L.
Cheilanthes gracilis (Fee) Mett.
Cheilanthes lanosa (Michx.) Walt.
Cheilanthes tomentosa Link.
Pellaea atropurpurea (L.) Link.
Woodsia obtusa (Spreng.) Torr.

MARSILEACEAE.

Marsilea vestita Hook & Green.

EQUISETACEAE.

Equisetum hyemale L.
Equisetum robustum A. Br.

SPERMATOPHYTA.

GYMNOSPERMAE.

PINACEAE.

Juniperus communis L.
Juniperus Virginiana L.

ANGIOSPERMAE.

MONOCOTYLEDONES.

TYPHACEAE.

Typha latifolia L.

ALISMACEAE.

Alisma Plantago-aquatica L.
Lophotocarpus calycinus (Engelm.) J. G. Smith.
Sagittaria ambigua J. G. Smith.
Sagittaria latifolia Willd.
Sagittaria longiloba Engelm.

GRAMINEAE.

Agropyron repens (L.) Beauv.
Agrostis alba L.
Agrostis heyemalis (Walt.) B. S. P.
Alopesurus geniculatus L.
Andropogon furcatus Muhl.
Andropogon scoparius Michx.
Andropogon Torreyanus Steud.
Aristida purpurea Nutt.
Bouteloua curtipendula (Michx.) Torr.
Bouteloua hirsuta Lag.
Bouteloua oligostachya (Nutt.) Torr.
Bulbilis dactylodes (Nutt.) Raf.
Calamovilfa longifolia Hack.
Capriola dactylon (L.) Kuntze.
Cenchrus tribuloides L.
Chrysopogon nutans L.
Cinna arundinacea L.
Dactylis glomerata L.
Dactyloctenium Aegypticum (L.) Willd
Distichlis spicata (L.) Green.
Etaonia obtusata (Michx.) A. Gray.
Elymus Canadensis L.
Elymus elymoides (Raf.) Swezey.
Elymus Virginicus L.
Eragrostis hypnoides (Lam.) B. S. P.
Eragrostis major Host.
Eragrostis pilosa (L.) Beauv.
Eragrostis Purshii Schrad.
Eragrostis secundiflora Presl.
Festuca octoflora Walt.
Gymnopogon ambiguus (Michx) B. S. P.
Homalocenchrus Virginicus (Willd) Britt.
Hordeum jubatum L.
Hordeum nodosum L.
Hordeum pusillum Nutt.
Ixophorus glaucus (L) Nash.
Ixophorus viridis (L) Nash.

Muhlenbergia diffusa Willd.
Muhlenbergia Mexicana (L.) Trin.
Panicum autumnale Bosc.
Panicum capillare L.
Panicum Crus-galli L.
Panicum obtusum H. B. K.
Panicum rostratum Muhl.
Panicum scoparium Lam.
Panicum Ccribnerianum Nash.
Panicum virgatum L.
Paspalum ciliatifolium Michx.
Paspalum laeve Michx.
Phalaris Caroliniana Walt.
Poa arachnifera Torr.
Poa arachnifera glabrata Vassey.
Poa compressa L.
Rattboellia cylindrica Chapm.
Sieglingia seslerioides (Michx.) Ssribn.
Sieglingia stricta (Nutt.) Kuntze.
Sorghum Halepense (L.) Pers.
Sorghum vulgare Durra.
Spartina cynosuroides (L.) Willd.
Sporobolus cryptandrus (Torr.) A. Gray.
Syntherisma sanguinalis (L.) Nash.
Tripsacum dactyloides L.
Uniola latifolia Michx.

CYPERACEAE.

Carex glaucodea Tucker.
Carex Muhlenbergii Schk.
Carex straminea brevior Dewey.
Carex vulpinoidea Michx.
Cyperus esculentus L.
Cyperus filiculmis Vahl.
Cyperus Houghtoni Torr.
Cyperus inflexus Muhl.
Cyperus ovularis (Michx.) Torr.
Cyperus pseudovegetus Steud.
Cyperus Schweinitzii Torr.
Cyperus strigosus L.
Eleocharis palustris (L.) R. & S.
Fimbristylus castanea (Michx.)—Vahl.
Scirpus Americanus Pers.
Scirpus atrovirens Muhl.
Scirpus lacustris occidentalis L.

Scirpus lineatus Michx.

ARACEAE.

Arisaema Dracontium (L.) Schott.

COMMELINACEAE.

Commelina nudiflora L.
Tradescantia Virginiana L.
Tradescantia Virginiana occidentalis Britt.

PONTEDERIACEAE.

Heteranthera limosa (Sw.) Willd.
Heteranthera reniformis R. & P.

JUNCACEAE.

Juncus marginatus Rostk.
Juncus tenuis Willd.
Juncus Torreyi Coville.

MELANTHACEAE.

Zygadenus elegans Pursh.

LILIACEAE.

Allium Nuttallii Wats.
Allium reticulatum Don.
Allium stellatum Knerr.
Androstephium coeruleum (Scheele) Green.
Erythronium mesachoreum Knerr.
Nothoscordum bivalve (L.) Britt.
Yucca glauca Nutt.

CONVALLARIACEAE.

Polygonatum commutatum (R. & S.) Dietr.

SMILACEAE.

Smilax Bona-nox L.
Smilax glauca Walt.
Smilax herebacea L.
Smilax hispida Muhl.
Smilax rotundifolia L.

AMARYLLIDACEAE.

Cooperia Drummondii Herb.

IRIDACEAE.

Sisyrinchium graminoides Bicknell.
Sisyrinchium augustifolium Nutt.

ORCHIDACEAE.

Gyrostachys cerunu Kuntze.

DICOTYLEDONES.

JUGLANDACEAE.

Hicoria glabra (Mill.) Britton.
Hicoria minima (Marsh.) Britt.

Hicoria Pecan (Marsh.) Britt.
Juglans nigra L.

SALICACEAE.

Populus deltoides Marsh.
Populus fluviatilis exigua (Nutt.) Sarg.
Populus nigra Marsh.

FAGACEAE.

Quercus acuminata Sarg.
Quercus alba L.
Quercus macrocarpa Michx.
Quercus Marylandica Muench.
Quercus minor (Marsh.) Sarg.
Quercus Muhlenbergii Engelm.
Quercus nigra L.
Quercus palustris. Du Roi.
Quercus prinoides Willd.
Quercus Prinus L.
Quercus rubra L.
Quercus velutina Lam.

ULMACEAE.

Celtis Mississippiensis Bosc.
Celtis occidentalis L.
Ulmus alata Michx.
Ulmus Americana L.
Ulmus fulva Michx.

MORACEAE.

Humulus Lupulus L.
Morus rubra L.

URTICACEAE.

Parietaria Pennsylvanica Muhl.
Urticastrum divaricatum (L.) Kuntze.

LORANTHACEAE.

Phoradendron flavescens (Pursh.) Nutt.

Polygonaceae.

Eriogonum alatum Torr.
Eriogonum annuum Nutt.
Eriogonum longifolium Nutt.
Polygonum aviculare L.
Polygonum convolvulus L.
Polygonum cristatum Engelm & Gray.
Polygonum emersum (Michx.) Britt.
Polygonum erectum L.
Polygonum Hartwrightii A. Gray.
Polygonum hydropiperoides Michx.

Polygonum lapathifolium L.
Polygonum littorale Link.
Polygonum longistylum Small.
Polygonum Mexicanum Small.
Polygonum Opelousanum Ridell.
Polygonum punctatum Ell.
Polygonum scandens L.
Polygonum tenue Michx.
Polygonum Virginianum L.
Rumex altissimus Wood.
Rumex crispus L.
Rumex obtusifolius L.

CHENOPODIACEAE.

Atriplex argentea Nutt.
Chenopodium album L.
Chenopodium Fremontii S. Wats.
Chenopodium hybridum L.
Chenopodium leptophyllum (Moq.) Nutt.
Chenopodium murale L.
Cycloloma atriplicifolia (Spreng.) Coult.
Dondia maritima L. Druce.
Monolepis Nuttalliana (R. & S.) Greene.

AMARANTHACEAE.

Acnida tamariscina (Nutt.) Wood.
Amaranthus blitoides S. Watson.
Amaranthus graecizans L.
Amaranthus hybridus L.
Amaranthus hybridus paniculatus (L.) Uline & Bray.
Amaranthus retroflexus L.
Amaranthus spinosus L.
Froelichia Floridana (Nutt.) Moq.
Froelichia gracilis Moq.
Iresine paniculata (L.) Kuntze.

PHYTOLACCACEAE.

Phytolacca decandra L.

NYCTAGINACEAE.

Allionia albida Walt.
Allionia hirsuta Pursh.
Allionia linearis Pursh.
Allionia nyctaginea Michx.

AIZOACEAE.

Mollugo verticillata L.
Sesuvium Maritinum (Walt.) B. S. P.

Sesuvium Portulacastrum L.

PORTUIACACEAE.

Claytonia Virginica L.
Portulacca pilosa L.
Talinum parviflorum Nutt.
Talinum teretifolium Pursh.

CARYOPHYLLACEAE.

Alsine media L.
Cerastium longipedunculatum Pursh.
Sagina decumbens (Ell.) T. & G.
Silene antirrhina L.
Silene stellata (L.) Ait.

NYMPHAEACEAE.

Castalia odorata (Dryand.) Woodv. & Wood.
Nelumbo lutea (Willd.) Pers.

ANONACEAE.

Asimina triloba Dunal.

RANUNCULACEAE.

Anemone Caroliniana Walt.
Clematis Simsii Sweet.
Delphinium Carolinianum Walt.
Hydrastis Canadensis L.
Myosurus minimus L.
Oxygraphis Cymbalaria (Pursh.) Prantl.
Ranunculus delphinifolius Torr.
Ranunculus Purshii Richards.
Thalictrum purpurascens L.
Thalictrum polygamum Muhl.

MENISPERMACEAE.

Cebatha Carolina (L.) Britton.
Menispermum Canadense (L.)

PAPAVERACEAE.

Argemone alba Lestib.
Argemone platyceras Link & Otto.

CRUCIFERAE.

Arabis Canadensis L.
Arabis Virginica (L.) Trelease.
Biscutella Wislizeni Watson.
Brassica juncea (L.) Cason.
Brassica nigra (L.) Koch.
Bursa Bursa pastoris (L.) Britton.
Draba Caroliniana Walt.
Draba cuneifolia Nutt.
Leavenworthia uniflora (Michx.) Britt.

Lepidium apetalum Wild.
Lepidium ruderale L.
Lepidium sativum L.
Lepidium Virginicum (L.) Willd.
Lesquerella densiflora Watson.
Roripa Nasturtium (L.) Rusby.
Roripa sessiliflora (Nutt.) A. S. Hitchcock.
Roripa sinuata (Nutt.) A. S. Hitchcock.
Sophia incisa (Engelm.) Greene.
Sophia pinnata (Walt.) Britt.
Sophia Sophia (L.) Britt.
Streptanthus hyacinthoides Hook.

CAPPARIDACEAE.

Cleomella angustifolium Torr.
Cristatella erosa Nutt.
Cristatella Jamesii T. & G.
Polanisia trachysperma T. & G.

CRASSULACEAE.

Sedum Torreyi Don.
Penthorum sedoides L.
Ribes aurem Pursh.

PLATANACEAE.

Platanus occidentalis L.

ROSACEAE.

Agrimonia mollis Britton.
Agrimonia parviflora Soland.
Fragaria Americana (Porter) Britton.
Geum Canadense Jacq.
Potentilla arguta Pursh.
Potentilla fruticosa L.
Potentilla Monspeliensis L.
Rosa Arkansana Porter.
Rosa foliolosa Nutt.
Rosa humilis Marsh.
Rubus Canadensis L.
Rubus hispidus L.

DRUPACEAE.

Prunus Americana Marsh.
Prunus gracilis Engelm. & Gray.

MIMOSACEAE.

Acacia filiculoides (Cav.) Trelease.
Acuan Illinoensis (Mich.) Kuntze.
Acuan leptoloba (T. & G.) Kuntze.

Morongia uncinata (Willd.) Britt.

CAESALPINIACEAE.

Cassia Chamaecrista L.
Cassia Marylandica L.
Cassia nictitans L.
Cercis Canadensis L.
Gleditsia triacanthos L.
Gymnocladus dioica (L.) Koch.
Hoffmansegia Jamesii T. & G.
Hoffmanseggia Falcaria Cav.

KRAMERIACEAE.

Krameria secundiflora Dc.

PAPILIONACEAE.

Amorpha canescens Pursh.
Amorpha fruticosa L.
Apios Apios (L.) MacM.
Astragalus Carolinianus L.
Astragalus gracilis Nutt.
Astragalus lotiflorus Hook.
Astragalus mollissimus Torr.
Astragalus Plattensis Nutt.
Astragalus racemosus Pursh.
Astragalus Reverchoni A. Gray.
Astragalus Tennesseensis Nut.
Baptisia australis (L.) R. Br.
Baptisia bracteata Ell.
Baptisia leucantha T. & G.
Clitoria Mariana L.
Cracca Virginiana L.
Crotalaria sagittalis L.
Falcata Pitcherie (T. & G.) Kuntze.
Galactia Volubilis (L.) Britt.
Glycyrrhiza lepidota Pursh.
Indigofera leptosepala Nutt.
Kuhnistera candida (Willd.) Kuntze.
Kuhnistera multiflora (Nutt.) Heller.
Kuhnistera purpurea (Vent.) MacM.
Kuhnistera villosa (Nutt.) Kuntze.
Lespedeza capitata Michx.
Lespedeza frutescens (L.) Britt.
Lespedeza procumbens Michx.
Lespedeza Stuvei Nutt.
Lespedeza violacea (L.) Pers.

Lotus Americanus (Nutt.) Bisch.
Medicago sativa L.
Meibomia Canadensis (L.) Kuntze.
Meibomia Dillenii (Darl.) Kuntze.
Meibomia grandiflora (Walt.) Kuntze.
Meibomia Illinoensis (Gray,) Kuntze.
Meibomia obtusa (Muhl.) A. M. Vail.
Meibomia paniculata (L.) Kuntze.
Meibomia rigida (Ell.) Kuntze.
Meibomia sessilifolia (Torr.) Kuntze.
Melilotus alba Lam.
Parosela aurea (Nutt.) Britt.
Parosela enneandra (Nutt.) Britt.
Parosela lanata (Spreng.) Britt.
Parosela nana Torr. & Heller.
Prosopis glandulosa Torr.
Psoralea argophylla Pursh.
Psoralea cuspidata Pursh.
Psoralea digitata Nutt.
Psoralea esculenta Pursh.
Psoralea floribunda Nutt.
Psoralea linearifolia T. & G.
Psoralea tenuifolia Pursh.
Rhynchosia tomentosa (L.) H. & A.
Robinia pseudacacia L.
Sesbania vesicaria Ell.
Sophora sericea Nutt.
Spiesia Lamberti (Pursh.) Kuntze.
Strophostyles helvola (L.) Britt.
Strophostyles pauciflora (Benth.) Wats.
Stylosanthes biflora (L.) B. S. P.
Stylosanthes biflora hispidissima Nutt.
Trifolium hybridum L.
Trifolium pratense L.
Trifolium repens L.
Vicia Americana Muhl.
Vicia linearis (Nutt.) Greene.
Vicia Leavenworthii T. & G.

GERANIACEAE.

Geranium Carolinianum L.

OXALIDACEAE.

Oxalis corniculata L.
Oxalis corniculata Dillenii Trelease.

Oxalis stricta L.
Oxalis violacea L.

LINACEAE.

Linum Berlandieri Hook.
Linum rigidum Pursh.
Linum sulcatum Riddell.
Linum usitatissimum L.

ZYGOPHYLLACEAE.

Kallstroemia maxima (L.) T. & G.

RUTACEAE.

Ptelea trifoliata L.
Xanthoxylum Americanum Mill.

POLYGALACEAE.

Polygala ambigua Nutt.
Polygala incarnata L.
Polygala verticillata L.

EUPHORBIACEAE.

Acalypha gracilens A. Gray.
Acalypha Virginica L.
Croton capitatus Michx.
Croton glandulosus L.
Croton Lindheimerianus Shreb.
Croton monanthogynus Michx.
Croton Texensis (Klotzsch.) Muhl.
Ditaxis mercurialina (Nutt.) Coult.
Euphorbia albamarginata T. & G.
Euphorbia corollata L.
Euphorbia dentata Michx.
Euphorbia dictyosperma F. & M.
Euphorbia Geyeri Engelm. & Gray.
Euphorbia glyptosperma Engelm.
Euphorbia heterophylla L.
Euphorbia hexagona Nutt.
Euphorbia humistrata Engelm.
Euphorbia longicruris Sheele.
Euphorbia maculata L.
Euphorbia marginata Pursh.
Euphorbia Nuttallii (Engelm.) Small.
Euphorbia petaloidea Engelm.
Euphorbia platyphylla L.
Euporbia serpens H. B. K.
Euphorbia serpyllifolia Pers.
Euphorbia stictospora Englem.
*Jatropha stim*ulosa Michx.

Ricinus communis L.
Stillingia sylvatica L.
Tragia nepetaefolia Cav.
Tragia ramosa Torr.

ANACARDIACEAE.

Rhus aromatica Ait.
Rhus copallina L.
Rhus glabra L.
Rhus radicans L.
Rhus trilobata Nutt.

CELASTRACEAE.

Celastrus scandens L.
Euonymus atropurpureus Jaq.

STAPHYLEACEAE.

Staphylea trifolia L.
Acer Negundo L.

SAPINDACEAE.

Sapindus marginatus Willd.

RHAMNACEAE.

Ceanothus Americanus L.

VITACEAE.

Ampelopsis arborea (L.) Rusby.
Ampelopsis cordata Michx.
Parthenocissus quinquefolia (L.) Planch.
Vitis cinera Engelm.
Vitis cordifolia Michx.
Vitis rotundifolia Michx.
Vitis rupestris Scheele.
Vitis vulpina L.

MALVACEAE.

Abutilon Abutilon (L) Rusby.
Callirrhoe digitata Nutt.
Callirrhoe involucrata T. & G.
Callirrhoe pedata Gray.
Hibiscus militaris Cay.
Hibiscus Trionum L.
Malvastrum coccineum (Pursh.) A. Gray.
Sida spinosa L.

HYPERICACEAE.

Ascyrum hypericoides L.
Hypericum Drummondii (Grev. & Hook.) T. & G.
Hypericum maculatum Walt.

CISTACEAE.

Lechea tenuifolia Michx.
Lechea villosa Ell.

VIOLACEAE.

Viola cuspidata?
Viola obliqua Hill.
Viola tenella Muhl.

PASSIFLORACEAE.

Passiflora incarnata L.
Passiflora lutea L.

LOASACEAE.

Mentzelia albicaulus. Dougl.
Mentzelia nuda (Pursh.) T. & G.
Mentzelia oligosperma Nutt.

CACTACEAE.

Opuntia humifusa Raf.
Opuntia polyacantha Haw.

LYTHRACEAE.

Ammannia coccinea Rottb.
Lythrum alatum Pursh.
Lythrum lanceolatum. Ell.

MELASTOMACEAE.

Rhexia Mariana L.

ONAGRACEAE.

Galpinsia Hartwegi (Benth.) Britton.
Gaura biennis L.
Gaura coccinea Pursh.
Gaura parviflora Dougl.
Gaura sinuata Nutt.
Gaura tripetala Cav.
Gaura villosa Torr.
Hartmannia speciosa (Nutt.) Small.
Jussiaea diffusa Forskl.
Lavauxia triloba (Nutt.) Spach.
Ludwigia alternifolia L.
Megapterium Missouriensis (Sims.) Spach.
Meriolix serrulata (Nutt.) Walp.
Meriolix serrulata spinulosa (T. & G.)—Small.
Oenothera laciniata Hill.
Oenthera lacinta grandis Britton.
Oenothera rhombipetala Nutt.
Onagra biennis (L.) Scop.
Stenosiphon linifolium (Nutt.) Britt.

UMBELLIFERAE.

Berula ercta (Huds.) Coville.
Chaerophyllum procumbens Shortii. T. & G.
Chaerophyllum Teinturieri Hook.
Cicuta maculata L.
Cynosciadium pinnatum DC.
Daucus pusillus Michx.
Eryngium acquaticum L.
Eryngium Leavenworthii T. & G.
Eurytaenia Texana T. & G.
Peucedanum foeniculaceum Nutt.
Polytaenia Nuttallii DC.
Ptilimnium Nuttallii (DC) Britt.
Sanicula Canadensis L.
Sanicula gregaria Bicknell.
Sanicula Marylandica L.
Spermolepis divaricatus (Walt.) Britton.

CORNACEAE.

Cornus asperifolia Michx.

PRIMULACEAE.

Androsace occidentalis Pursh.
Samolus ebracteatus H. B. K.
Samolus floribundus H. B. K.
Steironema ciliatum (L.) Raf.
Steironema lanceolatum (Walt.) Gray.
Steironema quadriflorum (Sims.) Hitch.

SAPOTACEAE.

Bumelia languinosa (Michx.) Pers.

EBENACEAE.

Diospyros Virginiana L.

OLEACEAE.

Fraxinus Americana L.
Fraxinus lanceolatus Brock.

LOGANIACEAE.

Polyperemum procumbens L.

GENTIANACEAE.

Eustoma Russellianum (Hook.) Griesb.
Sabbatia angularis (L.) Eursh.
Sabbatia angustifolia (L.) Uursh.
Sabbatia campestris Nutt.

APOCYNACEAE.

Apocynum androsaemifolium L.
Apocynum cannabinum Linn.
Apocynum hypericifolium Ait.

Apocynum pubescens R. Br.

ASCLEPIADACEAE.

Aceratus angustifolia (Nutt.) Dec.
Aceratus Floridana (Lam.) Hitch.
Aceratus viridiflora Ivesii Britton.
Aceratus viridiflora linearis A. Gray.
Ampelanus albidus (Nutt.) Britton.
Amsonia angustifolia Texana Gray.
Asclepias arenaria Torr.
Asclepias galioides H. B. K.
Asclepias incarnata L.
Asclepias latifolia Torr.
Asclepias obtusifolia Mich.
Asclepias pumila (A. Gray.) Vail.
Asclepias speciosa Torr.
Asclepias Sullivantii Engelm.
Asclepias Syriaca L.
Asclepias tuberosa L.
Asclepias verticillata Linn.
Asclepiodora decumbens (Nutt.) A. Gray.
Asclepiodora viridis (Walt.) Gray.
Vincetoxicum hirsutum (Michx.) Britton.

CONVOLVULACEAE.

Breweria Pickeringii (Curtis) Gray.
Convolvulus arvensis L.
Convolvulus repens L.
Convolvulus sepium L.
Evolvulus pilosus Nutt.
Ipomoea lacunosa L.
Ipomoea leptophylla Torr.
Ipomoea pandurata (L.) Meyer.
Ipomoea purpurea (L.) Roth.

CUSCUTACEAE.

Cuscuta cuspidata Engelm.
Cuscuta Polygonorum Engelm.

POLEMONIACEAE.

Gilia coronopifolia Pers.
Phlox pilosa L.

HYDROPHYLLACEAE.

Phacelia integrifolia Torr.

BORAGINACEAE.

Heliotropium convolvulaceum (Nutt.) A. Gray.
Heliotropium Curassavicum L.

Heliotropium tenellum (Nutt.) Torr.
Lappula Virginiana (L.) Greene.
Lithospermum angustifolium Michx.
Lithospermum canescens (Michx.) Hitch.
Lithospermum Gmelini (Michx.) Hitch.
Myosotis Virginica (L.) B. S. P.
Onosmodium Carolinianum (Lam.) DC.

VERBENACEAE.

Lippia cuneifolia (Torr.) Steud.
Lippia lanceolata Michx.
Lippia nodiflora (L.) Michx.
Verbena bipinnatifida Nutt.
Verbena bracteosa Michx.
Verbena Canadensis (L.) Britton.
Verbena hastata L.
Verbena stricta Vent.
Verbena urticaefolia L.
Verbena xutha Lehm.

LABIATEAE.

Agastache nepetoides (L.) Kuntze.
Hedeoma Drummondii Bent.
Hedeoma hispida Pursh.
Isanthus brachiatus (L.) B. S. P.
Koellia flexuosa (Walt.) MacM.
Lamium amplexicaule L.
Leonurus Cardiaca L.
Lycopus Americanus Muhl.
Mentha spicata L.
Monarda clinopodioides A. Gray.
Monarda fistulosa L.
Monarda punctata L.
Monarda scabra Beck.
Nepeta Cataria L.
Prunella vulgaris L.
Pysostegia Virginiana (L.) Benth.
Salvia lenceolata Willd.
Salvia Pitcheri Torr.
Scutellaria cordifolia Muhl.
Scutellaria lateriflora L.
Scutellaria parvula Michx.
Scutellaria resinosa Torr (?)
Stachys aspera Michx.
Teucrium Canadense L.

Teucrium laciniatum Torr.

SOLONACEAE.

Chamaesaracha Coronopus (Dunal.) A. Gray.
Chamaesaracha conioides (Morcand.) Britton.
Datura Metel L.
Datura Stramonium L.
Datura Tatula L.
Physalis angulata Linn.
Physalis comata Rydberg.
Physalis heterophylla Nees.
Physalis longifolia Nutt.
Physalis mollis Nutt.
Physalis Philadelphica Lam.
Physalis pubescens L.
Physalis rotundata Rydberg.
Physalis Virginiana Mill.
Quincula lobata (Torr.) Raf.
Solanum Carolinense L.
Solanum elaeagnifolium Cav.
Solanum Dulcamara L.
Solanum nigrum L.
Solanum rostratum Dunal.
Solanum Torreyi A. Gray.
Solanum triflorum Nutt.

SCHROPHULARIACEAE.

Buchnera Americana L.
Buchnera elongata Swartz.
Castilleja coccinea (L.) Spreng.
Conobea multifida (Michx.) Benth.
Gerardia aspera Dougl.—B.
Gerardia densiflora Benth.
Ilysanthes gratioloides (L.) Benth.
Leptandra Virginica L. Nutt.
Linaria Canadensis (L.) Dumont.
Mimulus alatus Soland.
Mimulus Jamesii T. & G.
Mimulus ringens L.
Monniera rotundifolia Michx.
Pentstemon acuminatus Dougl.
Pentstemon Cobaea Nutt.
Pentstemon Digitalis (Sweet.) Nutt.
Pentstemon grandiflorus Nutt.

Pentstemon hirsutus (L.) Wild.
Scrophularia Marylandica L.
Veronica peregrina L.

OROBANCHACEAE.

Orobanche Ludoviciana Nutt.

BIGNONIACEAE.

Tecoma radicans (L.) DC.
Martyniaceae.
Martynia Louisiana Mill.

ACANTHACEAE.

Dianthera Americana L.
Dianthera ovata Walt.
Ruellia ciliosa Pursh.
Ruellia strepens L.

PHRYMACEAE.

Phryma Leptostachya L.

PLANTAGINACEAE.

Plantago aristata Michx.
Plantago elongata Pursh.
Plantago lanceolata L.
Plantago major L.
Plantago occidentalis Dec.
Plantago Purshii R. & S.
Plantago Rugelii Dec.
Plantago Viginica L.

RUBIACEAE.

Cephalanthus occidentalis L.
Diodia teres Walt.
Galium Aparine Walt.
Galium circaezans Michx.
Galium pilosum Ait.
Galium trifldum L.
Houstonia angustifolia Michx.
Houstonia minima Beck.
Houstonia minor (Michx.) Britton.

CAPRIFOLIACEAE.

Sambucus Canadensis L.
Symphoricarpos Symphoricarpos (L.) Mac.
Triosteum perfoliatum L.
Viburnum prunifolium L.
Viburnum rufotomentosum Small.

VALERIANACEAE.

Valerianella radiata (L.) Duff.

CUCURBITACEAE.

Cucurbita foetidissima H. B. K.
Cylanthera dissecta (T. & G.) Arn.
Melothria pendula L.
Micrampelis lobata (Michx.) Greene.

CAMPANULACEAE.

Campanula Americana L.
Legouzia biflora (R. &. P.) Britt.
Legouzia leptocarpa (Nutt.) Britton.
Legouzia perfoliata (L.) Britton.
Lobelia cardinalis (L.) Britton.

CICHORIACEAE.

Hieracium longipilum Torr.
Lactuca Canadensis L.
Lactuca hirsuta Muhl.
Lactuca Ludoviciana (Nutt.) DC.
Lactuca sagittifolia Ell.
Lactuca Scariola L.
Lactuca spicata (Lam.) Hitchc.
Lygodesmia juncea (Pursh.) D. Don.
Nabalus altissimus (L.) Hook.
Nabalus asper (Michx.) T. &. G.
Serinia oppositifolia (Raf.) T. & G.
Sitilias Caroliniana (Walt.) Raf.
Sitilias grandiflora (Nutt.) Greene.
Sonchus asper (L.) All.

AMBROSIACEAE.

Ambrosia aptera DC.
Ambrosia artemisiaefolia L.
Ambrosia psilostachya DC.
Ambrosia trifida L.
Ambrosia trifida integrifolia (Muhl.) T. & Gray.
Iva ciliata Willd.
Iva xanthiifolia (Fresn.) Nutt.
Xanthium Canadense Mill.

COMPOSITAE.

Achillea Millefolium L.
Amphiachyris dracunculoides (DD.) Nutt.
Antennaria plantaginifolia (L.) Richards.
Anthemis Cotula Linn.
Aphanostephus skirrobasis (DC.) Trelease.

Artemisia dracunculoides Pursh.
Artemisia gnaphalodes Nutt.
Artemisia Ludoviciana Nutt.
Aster Drummondii Lindl.
Aster exilis Ell.
Aster multiformis Ait.
Aster oblongifolius Nutt.
Aster parviflorus A. Gray.
Aster patens Ait.
Aster patens gracilis Hook.
Aster sagittifolius Willd.
Aster salicifolius Lam.
Baccharis neglecta Britton.
Baccharis salicina T. & G.
Bellis integrifolia Michx.
Berlandiara lyrata Benth.
Berlandiara Texana DC.
Bidens bipinnata L.
Bidens laevis (L.) B. S. P.
Bidens trichosperma (Michx.) Britt.
Boltonia diffusa Ell.
Boltonia latisquama A. Gray.
Brauneria pallida (Nutt.) Britt.
Carduus altissimus L.
Carduus altissimus filipendulus A. Gray.
Carduus ochrocentrus (A. Gray.) Greene.
Carduus undulatus Nutt.
Carduus undulatus megacephalus (A. Gray.) Porter.
Centaurea Americana Nutt.
Chaetopappa asteroides DC.
Crhysopsis hispida (Hook.) Nutt.
Crhysopsis Nutallii Britton.
Crhysopsis stenophylla (A. Gray) Greene.
Crhysopsis villosa (Pursh.) Nutt.
Crhysopsis villosa canescens A. Gray.
Coreopsis grandiflora Hogg.
Coreopsis Peruviana (L.) Kuntze.
Coreopsis tinctoria Nutt.
Coreposis verticillata L.
Crassina grandiflora (Nutt.) Kuntze.
Dysodia papposa Vent.) A. S. Hitchcock.
Eclipta alba (L.) Haussk.

Elephantopus Carolinianus Willd.
Engelmannia pinnatifida T. & G.
Erigeron annuus (L.) Pers.
Erigeron divergens T. & Gray.
Erigeron Philadelphicus Skevish.
Erigeron ramosus (Walt.) B. S. P.
Erigeron ramosus Beyrichii (F. & M.) Smith & Pound.
Erigeron tenuis T. & Gray.
Eriocarpum rubiginosum (F. & G.) Britton.
Eriocarpum spinulosum (Nutt.) Greene.
Eupatorium ageratoides L.
Eupatorium altissimum L.
Eupatorium coelestinum L.
Eupatorium perfoliatum L.
Eupatorium serotinum Michx.
Euthamia Caroliniana (L.) Greene.
Flavaria angustifolia (Cav.) Pers.
Gaillardia lanceolata Michx.
Gaillardia pulchella Foug.
Gaillardia suavis (A. Gray) Britton & Rusby.
Gomphrena globosa albiflora Moq.
Grindelia lanceolata Nutt.
Grindelia squarrosa (Pursh.) Dunal.
Gutierrezia sarothrae (Pursh.) Britt.
Hoploesthes Greggi Gray.
Helenium autumnale L.
Helenium microcephalum DC.
Helenium tenuifolium Nutt.
Helianthus annuus L.
Helianthus decapetalus L.
Helianthus divaricatus L.
Helianthus laetiflorus Pers.
Helianthus Maximiliana Schrad.
Helianthus mollis Lam.
Helianthus petiolaris Nutt.
Helianthus scaberrimus Benth.
Helianthus strumosus L.
Heliopsis scabra Dunal.
Heterotheca subaxillaris (Lam.) Britton.
Hymenopappus tenuifolius Pursh.
Hymenatherum tagetoides Gray.
Isopappus divaricatus (Nutt.) T. & G.
Kuhnia eupatoroides L.

Lacinaria punctata Hook.
Lacinaria pycnostachya (Michx.) Kuntze.
Lacinaria scarioso (L.) Hiil.
Lacinaria squarrosa (L.) Hill.
Lacinaria squarrosa intermedia (Lindl.) Porter.
Leucelene ericoides Green.
Leptilon Canadense (L.) Britton.
Leptilon divaricatum (Mx.) Raf.
Lindheimera Texana Gray and Engelm .
Machaeranthera tanacetifolia Nees.
Mesadenia tuberosa (Nutt.) Britton.
Picradenia linearifolia (Hook.) Britton.
Picaradenia odorata (DC.) Britton.
Picaradenia scaposa (DC.) Britton.
Pluchea petiolaris Cass.
Polypteris Hookeriana (T. & G.) A. Gray.
Polypteris Texana A. Gray.
Psilostrophe arachnoides DC.
Psilostrophe Tagetinea (Nutt.) Kuntze.
Ratibida columnaris (Sims.) Don.
Ratibida columnaris pulcherrina Toor. & Gray.
Ratibida Tagetes (James.) Barnhart.
Rudbeckia amplexicaulus Vahl.
Rudbeckia hirta L.
Rudbeckia triloba L.
Senecio Plattensis Nutt.
Silphium intergrifolium Michx.
Silphium laciniatum L.
Silphium scaberrimum Ell.
Sitilias Caroliniana (Walt.) Raf.
Solidago arguta Ait.
Solidago Bigelovii A. Gray.
Solidago Boottii Hook.
Solidago Canadensis L.
Solidago erecta Pursh.
Solidago hispida Muhl (?)
Solidago juncea Ait.
Solidago Lindheimerana Scheele.
Solidago Missouriensis Nutt.
Solidago petiolaris Ait.
Solidago Radula Nutt.
Solidago rigida L.
Solidago rigidiuscula (T. & G.) Porter.

Solidago rugosa Mill.
Solidago rupestris Raf.
Solidago serotina Ait.
Solidago speciosa Nutt.
Solidago tortifolia Ell.
Taraxacum Taraxacum (L.) Karst.
Thelesperma gracile (Torr.) A. Gray.
Thelesperma tridifum (Poir.) Britton.
Verbesina alternifolia (L.) Britt.
Verbesina helianthoides Michx.
Verbesina occidentalis (L.) Walt.
Verbesina Virginica L.
Vernonia Baldwinii Torr.
Vernonia crinita Raf.
Vernonia Drummondii Shuttlw.
Vernonia fasciculata Michx.
Xanthisma Texanum D C.

BIRDS OF OKLAHOMA.

A. H. VAN VLEET.

INTRODUCTION.

The following list includes only those birds that have been collected and identified. Many of the more common ones are not included, as the collections were made, for the most part, during the trips in connection with the geological work, and special attention was given to collecting those that are rare or are difficult to obtain.

A catalogue of the birds is in preparation, and will be completed, it is hoped, for the next report.

LIST.

TURDIDAE: Thrushes, etc.

Harporhynchus rufus. Brown Thrush.
Mimus carolinensis. Catbird.
Mimus polyglottus. Mocking-bird.
Polioptila coerulea. Blue-gray Gnatcatcher.
Sialia sialis. Eastern Blue-bird.
Turdus migratorius. Robin.

PARIDAE: Titmice or Chichadees.

Lophophanes bicolor. Tufted Titmouse.
Parus atricapilus. Black-capped Chickadee.

SITTIDAE: Nuthatches.

Sitta carolinensis. Slender-billed Nuthatch.

TROGLODYTIDAE: Wrens.

Salpinctes obsoletus. Rock Wren.
Thryothorus ludovicianus. Great Carolina Wren.
Thryothorus bewicki. Bewick's Wren.

ALUAUDIDAE: Larks.

Eremophila alpestris. Horned or Shore Lark.
Eremophila lecuolaema. Western Shore Lark.

SYLVICOLIDAE: American Warblers.

Dendroeca aestiva. Summer Yellow-bird.
Dendroeca discolor. Prairie Warbler.
Dendroeca dominica albilora. White-browed Warbler.
Geothlypis trichas. Maryland Yellow-throat.
Helminthophila pinus. Blue-winged Yellow Warbler.
Icteria virens longicauda. Long-tailed Chat.
Protonotaria citrea. Prothonotary Warbler.
Selophaga ruticilla. American Redstart.

TANAGRIDAE: Tanagers.

Pyranga aestiva. Rose Tanager. Summer Tanager.
Pyranga rubra. Scarlet Tanager.

HIRUNDINIDAE: Swallows.

Cotile riparia. Bank Swallow.
Hirundo erythrogastra horreorum. Barn Swallow.
Petrochelidon lunifrons. Cliff Swallow.

AMPELIDAE: Chatterers.

Ampelis cedrorum. Cedar Waxwing.

VIREONIDAE: Vireos, or Greenlets.

Vireo articapillus. Black-capped Greenlet.
Vireo belli. Belle's Greenlet.
Vireo flavifrons. Yellow-throated Greenlet.
Vireo noveboracensis. White-eyed Greenlet.
Vireo olivaceus Red-eyed Greenlet.

LANIIDAE: Shrikes.

Lanius ludovicianus excubitorides. White-rumped Shrike.

FRINGILLIDAE: Finches, Buntings, Sparrows,, etc.

Astragalinus tristis. American Goldfinch .
Cardinalis virginianus. Cardinal Grosbeak.
Carpodacus purpurens. Purple Finch.
Centrophanes ornatus. Chestnut-collared Longsupr.
Chondestes graminica. Lark Sparrow.
Coturniculus passerinus. Grasshopper Sparrow.
Guiraca coerula. Blue Grosbeak.
Junco hiemalis. Black Snow-bird.
Melospiza fasciata. Song Sparrow.
Passer domesticus. House Sparrow.
Passerculus bairdi. Baird's Savanna Sparrow.
Passerella ilica. Eastern Fox-Sparrow.
Passerina circis. Painted Finch.
Passerina cyanea. Indigo Bird.
Pipilo erythrophthalmus. Towhee Bunting.
Pooecetes gramineus. Bay-winged Bunting.

Spiza americana. Black-throated Bunting.
Spizella agrestis. Field Sparrow.
Spizella domestica. Chipping Sparrow.
Spizella monticola. Tree Sparrow.
Zonotrichia leucophrys. White-browed Crown Sparrow.
Zonotrichia querula. Harris' Sparrow.

ICTERIDAE: Blackbirds etc.

Agelaeus phoeniceus. Red-winged Blackbird.
Icterus galbula. Baltimore Oriole.
Icterus spurius. Orchard Oriole.
Molothrus ater. Cowbird.
Quiscalus purpureus aeneus. Bronzed Crow Blackbird.
Scolecophagus cyanocephalus. Brewer's Blackbird.
Scolecophagus ferrugineus. Rusty Blackbird.
Sturnella neglecta. Western Meadow Lark.
Xanthocephalus icterocephalus. Yellow-headed Blackbird.

CORVIDAE: Crows, Jays.

Corvus frugivorus. Common American Crow.
Cyanocitta cristita. Blue Jay.

TYRANNIDAE: Flycatchers.

Contopus virens. Wood Pewee.
Empidonax trailli. Trail's Flycatcher.
Milvulus forficatus. Scissor-tail.
Myiarchus crinitus. Great Crested Flycatcher.
Sayiornis fusca. Phoebe.
Tyrannus carolinensis. King-bird. Bee-Martin.

CAPRIMULGIDAE: Goatsuckers.

Antrostomus carolinensis. Chuck-wills Widow.
Chordediles popetue. Night Hawk. Bull-bat.

CYPSELIDAE: Swifts.

Chaetura pelasgica. Chimney Swift.

TROCHILIDAE: Humming-birds.

Humming-birds are not uncommon in Oklahoma, but I have not had an opportunity to determine the species definitely. Two specimens collected by C. D. Bunker in Cleveland county, were, I think, Calypta costae. Unfortunately the skins were destroyed by mice, and the determination cannot be confirmed.

ALCEDINIDAE: Kingfishers.

Ceryle alcyon. Belted Kingfisher.

CUCULIDAE: Cuckoos.

Coccygus americanus. Yellow-billed Cuckoo.
Geococcyx californianus. Road Runner. Chaparral Cock.

PICIDAE: Woodpeckers

Centurus carolinus. Red-bellied Woodpecker.
Colaptes auratus. Flicker.
Colaptes mexicanus. Red-shafted Woodpecker.
Hylotomus pileatus. Pileated Woodpecker.
Melanerpes erythrocephalus. Red-headed Woodpecker.
Picus pubesens. Downy Woodpecker.
Picus scalaris. Texan Woodpecker.
Picus villosus. Hairy Woodpecker.

ALUCONIDAE: Barn Owls.

Aluco flammeus partincole. Barn Owl.

STRIGIDAE: Other Owls.

Asio accipitrinus. Short-eared Owl.
Scops asio. Screech Owl.
Speotyto cunicularia hypogaea. Burrowing Owl.
Strix nebulosa. Barred Owl. Hoot Owl.

FALCONIDAE: Vultures, Hawks, etc.

Accipiter cooperi. Cooper's Hawk.
Accipiter fuscus. Sharp-shinned Hawk.
Aquila chrysaetus. Golden Eagle.
Archibuteo ferrugineus. Ferruginous Rough-legged Buzzard.
Archibuteo lagopus sancti johannis. American Rough-legged Buzzard.
Buteo borealis. Red-tailed Buzzard.
Buteo harleni. Harlan's Buzzard.
Buteo lineatus. Red-shouldered Hawk.
Buteo swainsoni. Swainson's Buzzard.
Falco sparverius. Sparrow Hawk.
Haliaetus leucocephalus. Bald Eagle.
Ictinia subcoerulea. Mississippi Kite.
Pandion haliaetus. Osprey.

CATHARTIDAE: American Vultures.

Catharista atrata Carrion Crow.
Cathartes aura. Turkey Buzzard.

COLUMBIDAE: Pigeons.

Zenaidura carolinensis. Mourning Dove.

MELEAGRIDIDAE: Turkeys.

Meleagris gallipavo americana. Wild Turkey.

TETRAONIDAE: Grouse, Partridge, Quail.

Cartonyx massena. Massena Partridge.
Cupidonia cupido. Pinnated Grouse. Prairie Hen.
Ortyx virginiana. Quail. Bob-white.

CHARADRIIDAE: Plover.

Aegialites cantianus nivosus. Snowy Ring Plover.

Aegialites vociferus. Kildeer Plover.

RECURVIROSTRIDAE: Avocets. Stilts.

Himantopus mexicanus. Stilt.
Recurvirostra americana. American Avocet.

PHALARODIDAE: Phalarope.

Steganopus wilsoni. Wilson's Phalarope.

SCOLOPACIDAE: Snipes.

Actodromas bairdi. Baird's Sandpiper.
Actodromas maculata. Pectoral Sandpiper.
Actodromas minutilla. Least sandpiper.
Bartramia longicauda. Bartramian Sandpiper.
Ereunetes pusillus. Semipalmated Sandpiper.
Gallinago wilsoni. Wilson's Snipe.
Numenius longirostris. Long-billed Curlew.
Rhyacophilus solitarius. Solitary Tattler.
Symphemia semipalmata. Willet.
Totanus flavipes. Lesser Tell-tale.
Totanus melanoleucus. Greater Tell-tale.

ARDEIDAE: Herons.

Ardea herodius. Great Blue Heron.
Ardetta exilis. Least Bittern.
Botaurus mugitans. American Bittern.
Butorides virescens. Green Heron.
Florida coerula. Little Blue Heron.
Herodias Egretta. Great White Egret.
Nycterodius violaceus. Yellow-crowned Night Herron.
Nyctiardea grisea naevis. Black-crowned Night Herron.

GRUIDAE: Cranes.

Grus americana. Whooping Crane.
Grus canadensis. Northern Brown Crane.
Grus pratensis. Southern Sand-hill Crane.

RALLIDAE: Rails.

Porozana carolina. Common Rail. Sora.
Rallus elegans. King Rail.
Fulica americana. American Coot. Mud-Hen.

ANATIDAE: Geese, Ducks, etc.

Aix sponsa. Wood Duck.
Anas boscas. Mallard.
Anas obscura. Black Duck.
Anser albifrons gambeli. American White-fronted Goose.
Bernicla canadensis. Canada Goose.
Bernicla canadensis leucoparia. Smaller White-cheeked Goose.
Chaulelasmus streperus. Gadwell. Gray Duck.
Chen albatus. Lesser Snow Goose.

Chen coerulescens. Blue Snow Goose.
Clangula albeola. Buffle-head. Dipper.
Cygnus buccinator. Trumpeter Swan.
Dafila acuta. Pin-tail Duck. Sprig-tail.
Erismatura rubida. Ruddy Duck.
Fuligula affinis. Lesser Scaup Duck.
Fuligula collaris. Ring-neck Duck.
Fuligula americana. Red-head.
Mareca americana. American Wigeon. Bald-pate.
Mergus merganser. Merganser.
Querquedula carolinensis. Green-winged Teal.
Querquedula discors. Blue-winged Teal.
Spatula clypeata. Shoveller Duck.

PELECANIDAE: Pelicans.

Pelecanus trachyrhynchus. White Pelican.

LARIDAE: Gulls, Turns, etc.

Chroicocephalus franklini. Franklin's Rosy Gull.
Sterna superciliaris antillarum. Least Tern.

PODICIPEDIDAE: Grebes.

Podilymbus podiceps. Pied-billed Grebe.

SNAKES OF OKLAHOMA.

A. H. VAN VLEET.

INTRODUCTION.

This is not an attempt to give a complete catalogue of the snakes of Oklahoma. Only such forms are included as are in the collection of the Survey. No formal report of this very interesting and important group of animals, for the territory, has, to my knowledge, ever been published, and it is hoped that this may form a nucleus for future additions. With this aim in view it has seemed best to exclude all doubtful forms, for when a species or variety has once been erronously reported it is hard to correct the error. It is deemed wise, then, to err on the safe side, even though the list be considerably reduced thereby.

The classification is the same as that used by Cope in his report on the Crocodiles, Lizards, and Snakes of the National Museum.

While detailed descriptions have been entirely omitted, the common name, as far as possible, has been given, together with such other information as would lead those unacquainted with the scientific nomenclature to recognize the different forms.

With reference to their food all snakes are carniverous, and almost without exception catch and kill their own food. All of them are, without doubt, more or less insectiverous, and the large numbers of moles, mice, gophers etc., consumed by them, render them of the greatest importance to the agriculturalist. A large "Bull Snake" on the farm is worth a dozen cats, and yet most people would walk a half mile to get a club to kill one with. Nearly all of our snakes are harmless and valuable, and people should learn to distinguish between those that are harmless and those that are poisonous, and there should be a law protecting the harmless ones, just as there is a law protecting birds that are of value to the agriculturist.

A great "terror of snakes" is almost universal, and though it is universal, it is also worse than foolish. In law persons are considered innocent until proved guilty; but all snakes are considered guilty, and although the majority of them never did anything worse than to kill a few insects, frogs, or mice, they are condemned to death at sight.

I want to enter a strong plea for the lives of these harmless and valuable animals; and when the argiculturalist learns their true worth, he will no longer regard them as enemies to be killed, but as benefactors to be carefully protected.

CATALOGUE.

CARPHOPHIOPS Gervais.

This genus includes two species, and they are both found in Oklahoma. They are generally known as Worm Snakes. They are small perfectly harmless, and are generally found under and in old rotten logs, and under stones. This habit of burrowing and hiding makes them difficult to find, and they never seem to be common in any locality.

CARPHOPHIOPS AMOENUS. Say.

One specimen from near Norman.

CARPHOPHIOPS VERMIS. Kennicott.

One specimen from near Norman.

DIADOPHIS. Baird and Girard.

The snakes of this genus are also small and harmless. Their habits are similar to those of Carphophiops. Their food consists mainly of insects and larvae of various kinds.

But one species is represented in the collection of the Survey.

DIADOPHIS AMABOLIS DOCILIS. Baird and Girard.

One specimen from near Norman, Oklahoma.

HETERODON. Latreille.

These snakes are known as Blow Snakes, Blowing Vipers, Spreading Adders, Hog-nosed snakes etc. The last name comes from the peculiar up-turned extension of the rostral plate; the others from the habit these snakes have, when disturbed, of swelling out and flattening the head, uttering at the same time a loud hissing noise.

It is next to impossible to convince people that the "Blow Snake" is not poisonous. It is a common belief that they "blow" their poison. I have seen persons turn "deathly sick" on seeing and hearing one of these snakes "blow," fully believing that poison had been "blown" into their faces, when the truth is, they have no poison to "blow." They are perfectly harmless, and this assumption on their part of being dangerous is merely a bluff to protect themselves against their enemies.

Their food is made up largely of insects, larvae, and worms.

HETERODON PLATYRHINUS. Latreille. Spotted form.

Common throughout the territory.

HETERODON PLATYRHINUS, Latreille.Black form.

There is one fine specimen on the collection collected by W. A. Tucker, near Norman.

HETERODON NASICUS NASICUS. Baird and Girard.

Common throughout the territory.

HETERODON NASICUS KENNERYLI. Kennicott.

One specimen from near Norman.

CYCLOPHIS. Gunther.

There is but one species of this genus in the Western Hemisphere. This snake is very slender, green above, below, light yellow. It is harmless, and seemingly rare, but this likely is due more to its protective colloring than to its real scarcity.

CYCLOPHIS AESTIVUS. Linnaeus. Green Snake.

One specimen from the Canadian river, west of Norman, collected by George A. Bucklin.

ZAMENIS. Wagler.

Two species of this genus are common in Oklahoma. Zamenis constrictor Linnaeus, and Zamenis flagellum Shaw. The former are known as "Blue Racers," and the latter as "Coach Whips."

They are harmless, and as they devour large numbers of insects and small animals, they deserve protection.

ZAMENIS CONSTRICTOR. Linnaeus.

Common throughout the territory. The so-called green and yellow form is the only kind that I have seen in Oklahoma.

ZAMENIS CONIROSTRIS. Cope.

I hesitate to record this species with certainty, as the species was founded on a single specimen from Matamoris, Mexico; but the specimen is so typical that there can hardly be a mistake. The shape of the head corresponds exactly with the description and plates of this species in Cope's report on the Crocdiles, Lizards, and Snakes of the National Museum. There are eight superior labials which are perfectly normal in appearance, and the expanded front of the frontal plate is in contact with the preoculars.

ZAMENIS FLAGELLUM FLAGELLUM. Shaw.

Very common throughout the territory.

COLUBER. Linnaeus.

This genus includes some of our largest snakes, the "Black Snake" of the East being one of the best-known representatives. They are all harmless. Some of them are expert climbers, and birds and eggs enter largely into their bill of fare.

I have been unable to determine the species to my satisfaction. More material is necessary. There are four good specimens, one small and three large ones. On first examination these would be referred to at least three different species; but on closer study, I have referred them all to one.

COLUBER OBSOLETUS OBSOLETUS. Say.

The smaller specimen has the ordinary markings of quadrangular dark blotches with white intervals. One of the large ones is almost uniformly dark brown with indications of blotches, while another one has the white markings replaced by deep reddish chocolate. The other one is intermediate between these two. While these color variations seem extreme for the same locality, I believe they all belong to the above species and variety.

Three are from near Norman. The one with the red markings was collected by the writer near the mouth of a large gypsum cave in Woodward county.

PITYOPHIS. Holbrook.

These are known as "Bull snakes." They are perhaps the most common of our snakes, and are very valuable to the farmer as they devour large numbers of moles, gophers, mice, young rabbits etc.

I have found but one species and one variety in the territory.

PITYOPHIS SAYI SAYI. Schlegel.

Common throughout the territory.

OSCEOLA. Baird and Girard.

This genus includes a number of rather small, and for the most part bright colored snakes. They are all harmless, and live upon insects, larvae, etc.

OSCEOLA DOLIATA COCCINEA. Schlegel.

One specimen collected near Norman. It is probably common in the territory, as it is a widely distributed variety.

OSCEOLA DOLIATA ANNULATA. Kennicott (?)

One specimen from near Norman. There is great color variation in these varieties, and this seems to be an intermediate form. I have *recorded it provisionally* as annulata.

OPHIBOLUS. Baird and Girard.

This genus is represented by two species in the collection.

ORPHIBOLUS CALIGASTER. Say. House Snake.

Common thoroughout the territory. It is harmless, gentle in its disposition, and should be protected, as it devours large numbers of insects, mice, etc.

OPHIBUS GETELUS SAYI. Holbrook. King Snake.

There are three specimens in the collection, all from near Norman, but it is probably quite common throughout the territory.

It is harmless, and lives upon moles, mice, lizards, and snakes. The belief is quite prevalent that this snake is the enemy of the Rattlesnake and Moccasin. It has received the name "King Snake" because of its reputed prowess in killing poisonous snakes. That it kills and devours large numbers of snakes seems certain, but that it has a preference for the poisonous varieties is not so well established.

NATRIX. Laurenti.

This genus includes the water snakes. They are very widely distributed, and are common everywhere along the streams. Although quite pugnacious in character, they are really harmless.

Two species are represented in the collection, Natrix fasciata, and Natrix rhombifera.

The former includes a number of varieties with more or less definite geographical ranges, and the specimens on hand do not seem to be typical of any of these varieties. I have placed them provisionally under:

NATRIX FASCIATA SIPEDON LINNAEUS.

This whole group will require further and careful study with a much larger collection at hand.

NATRIX RHOMBIFERA. Hallowell.

Very common throughout the territory. This species seems to be quite terrestial in its habits. Nearly all that I have found were on low, moist ground, but some distance from water. The name "Dry land" Moccasin is often erroniously applied to it.

EUTENIA. Baird and Girard.

This genus includes a great number of species and varieties which are commonly known as "Garter Snakes."

They are harmless, and have an enviable reputation as such, the expression "harmless as a garter snake" being a very common one. The